PUBLIC TRANSPORT COMMISSION OF NEW SOUTH WALES

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85 CLASS ELECTRIC LOCOMOTIVES

INTERIM
OPERATING INSTRUCTIONS

F. A. GODFREY,
OPERATIONS MANAGER, LOCOMOTIVE

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PTC.79-25

GENERAL DESCRIPTION

The 85 class electric locomotive is employed in the haulage of freight and passenger trains over the various lines within the electrified area. General particulars are as follows:-

Voltage	1500 D.C.
Wheel arrangement	CO - CO
Mass	120 tonnes
Axle load	20 tonnes
Wheel diameter	1250 mm
Bogie wheel base	4000 mm
Total wheel base	14400 mm
Length over buffers	19000 mm
Overall width	2883 mm
Height from rail level to pantograph lowered	4330 mm
Horse power	2700 kW
Maximum speed	115 km/h
Low tension supply	120 D.C.
Dead hauling mass	125 tonnes

Cab

The locomotive has a driving position at each end with suitable accommodation for the enginemen.

Housed within the locomotive is the control equipment, traction motor blowers, starting resistances, blower fans, and motor alternator set.

Two electrically driven compressors are mounted on the underframe, also the battery charger and batteries.

Traction Motors

There are six (6) traction motors, three on each bogie giving traction on all wheels. Each traction motor is supported by axle suspension bearings. A lateral hydraulic snubber is provided on the bogie located adjacent to the inner axle. The introduction of this type of snubber should improve riding characteristics. In addition, two traction snubbers are used to control swivelling of the bogie.

Shrunk onto the motor armature shaft is a pinion that meshes with a drive gear pressed onto the driving axle. The gear ratio between the pinion and the drive gear is expressed by two figures, such as 79/20 for the 130 km/h gearing used on this locomotive. The first number indicates the number of

teeth on the drive gear and the second the number of teeth on the pinion.

Armature bearings are of the roller type and axle suspension bearings are also roller bearing type.

Control Equipment

The control equipment is arranged for the motors to be connected either six in series, two parallelled circuits each of 3 motors in series, or three parallel circuits each of two motors in series. Four weak field positions are provided in each combination. Contactors are of the electro-pneumatic type.

Resistances are of strip metal type. They are provided with blowers which come into operation when the resistances are in circuit for over a prescribed time.

Provision is made for regenerative braking in series and series-parallel.

The control voltage is 120 D.C.

Batteries

The batteries consist of 54 cells of the lead acid type with a capacity of 55 amps hours.

The battery switch being a double pole knife type located on the upper portion of the circuit breaker panel.

Motor Alternator (MA) Set

The motor alternator (MA) set produces three phase 415 volts of current for the operation of the traction motor blowers, starting resistance fan motors, hot plates, cab heaters, air conditioning and alternating current (AC) control apparatus. Portion of this current is rectified to 120 volts DC for operation of the control circuit and battery charging.

A separate three phase supply is provided by the motor alternator for regenerative braking.

The control circuit of the motor alternator (MA) set is protected by the motor alternator control circuit breaker (M.A.C.B) located on the circuit breaker panel and it is essential that it be "on" to permit continuous operation of the motor alternator while ever the locomotive is in service.

High tension current from the overhead drives the machine and protection is provided by the Differential Current Detector and overcurrent relay (M.A.O.C.R.) through the operation of the High Speed Circuit Breaker.

The three phase 415 volt output has an overvoltage protector and in addition is protected by the alternator current (AC) circuit breaker located on the wall adjacent to the alternator.

Regenerative brake excitation supply is protected by three large fuses bolted to the wall adjacent to the motor alternator and are not to be renewed by engineman.

Should a defect develop on the motor side Of the alternator, the motor alternator overcurrent relay (M.A.O.C.R.) will operate and trip the High Speed Circuit Breaker, isolating the 1500 volt overhead supply to the motor alternator. Similarly, an overvoltage relay (OVD) protects the output side of the motor alternator and should a defect develop, OVD energises the motor alternator overvoltage relay (M.A.O.V.R.) which de-energises the motor alternator contactor (MAC). This interrupts high tension current supply to the motor alternator and upon it being stopped, the alarm circuit is energised.

Operation of the motor alternator overcurrent relay (M.A.O.C.R.) will cause both the blue and red lights to shine and the alarm bell to sound.

The tripping of the overvoltage relay (M.A.O.V.R.) will cause the motor alternator output to be interrupted, the blue light will shine and alarm bell will sound.

The motor alternator overcurrent relay M.A.O.C.R. and M.A.O.V.R. are reset and the warning lights and bell cancelled by operating the fault reset button on the driver's stand.

Supply Isolate Switch (SIS)

This switch is located on the circuit breaker panel and is normally on. Should a defect develop or it becomes necessary to isolate the motor alternator for any reason, the switch is to be turned "Off". This action also isolates the blue light and bell.

Supply Indicating Relay (SIR)

This relay is located on the 120 volt side of the battery charger and operates the blue light and alarm to indicate that the output from the alternator is lost, due to the motor alternator (AC) control circuit breaker, battery charger circuit breaker (BACB) or supply indicator circuit breaker (SIRB) tripping out.

Under normal circumstances, the blue light and bell will be cancelled when the circuit breaker is reset.

Remote Supply Circuit Breaker

If the batteries are discharged to the point where the auxiliary machines cannot be started, provision is made in the jumpers to obtain a 120 V remote supply from a battery charger on another 85 class locomotive. This is connected when jumper couplings are inserted and Remote Supply circuit breaker (RSB) seal is broken and switched "ON" on both locomotives. The operation of the circuit breakers will cancel the "Failed Alternator" indication and alarm by energising the "Supply Indicating relay" (S.I.R.).

Once the auxiliary machines are started the "Remote Supply Circuit breakers" on both locomotives must be opened and the defect recorded in the log book.

Note: In the event of the motor alternator failing on a locomotive in a multiple consist, control circuit current (120 volt) can be obtained by adopting this procedure but in all cases the control circuit cut out switch (CCOS) must be located in the "off" position on the locomotive with the failed motor alternator, in addition lower pantographs and turn off supply isolating switch (SIS).

External Alternating Current (AC) Power Supply

An external alternating current (A.C.) Power supply socket and switch are mounted on the underframe at No. 1 end of the locomotive. This is used by the maintenance staff to test the locomotive without having the 1500 V supply.

This switch should be carried in the "Normal" position.

NOTE: The sequence test switch controlling supply is next to the control circuit cutout switch (CCOS) in the electrical cabinet.

COMPRESSORS

There are two air compressors each having a displacement of 2 cubic metres per minute and is driven by a 1500 volt motor.

BRAKE EQUIPMENT

Locomotive class 85 (8501 - 8510) will be equipped with automatic 26L self lapping, brake pipe pressure maintaining, type of brake equipment. This system functions by employing the same 4 pipe arrangement as applies for the A7-B7EL type, i.e. the locomotive pipes are designated Brake Pipe, Main Reservoir,

Control and Independent Release. Thus it functions in conjunction with, and under control of, other locomotives fitted with A7-B7EL systems both in the automatic and independent aspects. Following is a description of the arrangement and use of the 26L equipment for the guidance of Enginemen.

The Basic components of the system are:-

Automatic Brake Valve

This valve is designed to provide self lapping, brake pipe pressure maintaining conditions, which means that for any brake valve handle position in the "service" range a given brake pipe reduction applies, pressure, at the reduced level, being maintained against reasonable leakage. Under such a condition, once a certain level of braking has been set by a given reduction in brake pipe pressure this degree of braking remains constant and does not increase as applies with earlier equipment under normal conditions of brake pipe leakage.

No rotary valve is incorporated in this item, the distribution of air for the various functions of the brake valve being controlled by cam operated spool valves and flexible diaphragms.

Regulating Valve

Mounted in the upper left hand part of the Automatic Brake Valve assembly. This valve serves a similar purpose to the feed valve on earlier equipment and provides a means of manual adjustment to brake pipe pressure. The control spindle is rotated clockwise (screwed in) to increase pressure and anti-clockwise to decrease pressure.

Brake Valve Cut Off Valve

Mounted in the upper front area of the Automatic Brake Valve assembly and serves a similar purpose to the driver's brake valve isolating cock in earlier equipment. The valve control knob can be located in two positions.

IN when the associated brake valve controls the train (point horizontal).

OUT when the associated brake valve is isolated (point vertical). (i.e. is rendered incapable of charging the train).

Automatic Brake Valve Operation

The automatic brake valve has 6 handle positions i.e. Release, Minimum Reduction, Full Service, Suppression, Handle Off and Emergency.

Release position charges the brake pipe and is the normal position during running without a brake application. THERE IS NO FULL RELEASE function - all brake pipe charging occurring per medium of the regulating and relay valves. The Regulating Valve is set at normal pipe pressure requirements.

Minimum Reduction position provides and maintains a 45 - 55 kPa reduction in brake pipe pressure.

Service range covers the zone from minimum reduction to full service. In this zone a given brake pipe pressure reduction exists, and is maintained, for any brake valve handle position - only as the handle is moved to the right, i.e., as the degree of reduction is increased. In the full service position the brake pipe pressure is reduced by 175 kPa. When the handle is moved to the left no increase in brake pipe pressure occurs until the "release" location is arrived at.

Suppression position is not used with our locomotives and can be considered as a "Full Service" position.
Main reservoir pressure is directed to the vigilance control equipment for suppression.

Handle Off position renders the normal functions of a brake valve inoperative whilst the brakes are being controlled from another brake valve on the same or an attached locomotive. In this position the equalising reservoir is vented to atmosphere.

The "handle off" position functions in conjunction with the "brake valve cut off valve" when the latter should be set in the "out" position.

The "handle off" position may be used on a leading locomotive with brakes cut in so as to apply the brakes to a degree exceeding a service condition. In such a case the brake pipe is reduced at a "service" rate to approximately 70 kPa.

Main reservoir pressure is directed to the vigilance control equipment for suppression.

Emergency position vents the brake pipe to zero at a fast rate and provides maximum brake cylinder pressure rapidly throughout the train.

Main reservoir pressure is directed to the vigilance control equipment for suppression.

Independent Brake Valve

This valve is cam operated and Self lapping and like the auto - brake valve does not incorporate a rotary valve. Similar facilities are provided to those available with the use of existing equipment, i.e.

(a) the locomotive brakes can be applied and released independently of the automatic system.

(b) the locomotive brakes can be released whilst an automatic brake application is in operation on the locomotive and train.

Two operating positions apply for the handle:-

"Release" at the extreme left and,

"Full Application" at the extreme right.

Between these positions is the application zone in which for any given handle position a particular brake cylinder pressure applies. This condition exists both when the handle is being moved to the right (increasing pressure) or left (decreasing pressure). Maximum setting is 325 kPa.

Depression of the handle whilst it is in the "application zone" provides a quick release feature for an "automatic" application the brake cylinder pressure however, only being reduced to that which corresponds to the independent handle position. Thus for a complete "quick release" of an automatic application the independent handle must be depressed in the "release" position. The independent brake valve handle is removable in the "Release" position and all pedestals, except that from which the locomotive is being controlled should have their independent brake valve set in the "Release" position.

Control Valve

Performs a similar function to the distributing valve of the A7-B7EL equipment.

Under the effect of pressures dictated by the various brake valve (both automatic and independent) functions, this valve controls the degree of brake cylinder pressure development per medium of a Relay Valve.

MU 2A Valve is mounted on the lower L.H. front face of the brake pedestal and is provided ONLY FOR THE PURPOSE OF "CUTTING IN" OR "ISOLATING" THE INDEPENDENT BRAKE VALVE ON THE SAME PEDESTAL.

When "CUT IN" (Lead or Dead) the pointer is vertically upwards.
When "ISOLATED" (Trail) the pointer is horizontal.

Regardless of the number of MU valves on a locomotive or group of locomotives working multiple all other than the MU valve at the controlling pedestal should be set at "Trail".

In order to determine the required setting for each valve the following rules should be observed:-

(1) LEADING LOCOMOTIVES

Where a locomotive leads and/or controls a train the MU valve, at the pedestal from which it is being driven, must be set at "Lead or Dead".

(2) PUSHER OR BANK ENGINES

With this working when locomotives are situated remotely from the leading locomotive the conditions in (1) also apply.

(3) TRAILING LOCOMOTIVES (working multiple)

Where this condition applies the setting of the MU valve depends entirely on whether the No. 3 independent hose of a trailing locomotive is coupled to and being fed from the corresponding hose on the leading locomotive.

When the No. 3 hoses are coupled the setting is "Trail"
When the No. 3 hoses cannot be coupled the setting is "Lead or Dead".

Flow Meter

This section of the equipment is the same and provides similar operating facilities as available with A7-B7EL systems.

Dead Engine Device

Consists of a cock, which is normally closed, and a spring loaded check valve. When the cock is open Brake Pipe Air is fed to charge the No.2 Main Reservoir of a "dead" locomotive. The check valve only allows No. 2 Main Reservoir to reach a pressure of 150 kPa below the brake pipe pressure involved. This device is cut in under similar conditions to those which apply for the use of A7-B7EL equipment on existing locomotives.

Regenerative Interlock

This function occurs by means of a magnet valve which is energised whilst regeneration brake procedures are being observed. When it is in use the automatic brake is not available on the locomotive but the independent system can be used, care being observed to limit brake cylinder pressure so as to avoid wheel skidding.

When the brake pipe pressure is reduced below 250 kPa the regenerative brake is rendered inoperative by a pneumatic control switch in a similar manner as applies with A7-B7EL systems.

Emergency Cock

This is located to the right of the pedestal near floor level. The handle of this cock points upwards when closed and movement of it to the horizontal position will vent the brake pipe directly to the atmosphere. Under this condition the cut off valve should be set in the "OUT" position.

Main Reservoir Drain Valves

A new type of automatic drain valve is fitted to the main reservoir and under normal conditions will drain all water from the main reservoirs. However, should the air valve not seat effectively air will escape from the opening in the base.

If loss of main reservoir pressure in service occurs and it is found to be due to this cause, the body of the valve may be lightly tapped to reseat the valve.

MOTOR COMBINATIONS

Each locomotive is equipped with six traction motors which are axle mounted. Motors Nos. 1, 2 and 3 are on one bogie and motors Nos. 4, 5 and 6 on the other bogie.

Powering circuit

(a) Series connection

The six traction motors and two groups of starting resistances are connected in series.

The starting resistance is cut out step by step by the resistance camshaft under current limit control.

(b) Series-Parallel connection

The traction motors are connected into two parallel groups each group with three traction motors in series. The two resistance groups are connected in parallel.

(c) Parallel connection

The traction motors are connected in three parallel groups with two traction motors in series.

The two resistance groups are connected in parallel.

(d) Field weakening

Can occur in each motor grouping. There are four steps of weak field. All motors are connected for maximum weak field at starting.

Line Volt Meter

A line volt meter is located at roof level in the left corner of the driving cab and indicates the overhead line voltage.

Control Circuit Cut Out Switch (CCOS)

The control circuit cut out switch is located in the Electrical Cupboard and is labelled "ON" and "OFF".

In the "ON" position normal operation is available but in "OFF" position the power circuit for traction motor operation is isolated, together with the red fault light and alarm bell.

However, the placing of the control circuit cut out Switch (CCOS) does not prevent the control circuit from being operated by the accelerating handle, regenerative handle and reverser on the isolated locomotive, which permits power to be applied on trailing locomotives from the leading locomotive when it is "dead".

Supply Isolate Switch (SIS)

This switch is located on the circuit breaker panel and is labelled "ON" and "OFF".

When moved to the "OFF" position it isolates the motor alternator and also the alarm circuit; blue light and bell.

LOAD METER (AMMETER)

The load meter is of the centre zero type, clockwise motoring, and anti-clockwise regen brake with a continuous rating zone extending up to 690 amps and an overload zone coloured red for both motoring and when operating in regenerative brake. One hour rating under full power is 725 amps.

CONTROL CIRCUIT

The control circuit consists of battery charging, control and small motor circuits, contactor and relay coils, lighting circuits and air conditioning.

The control circuits are protected from overload by numerous magnetic circuit breakers and fuses.

A magnetic circuit breaker protects the circuit from an overload of current in a similar manner to a thermal type. It has a magnetic coil and spring loaded armature plate incorporated in the switch.

When the amperage exceeds the value of the circuit breaker, the magnetic coil overcomes the tension of the spring and moves the armature plate sufficiently, to permit the switch to trip off and open the circuit. The toggle portion of these switches displays a white band which provides a positive indication of whether the circuit breaker is switched 'on' or 'off'.

Three (3) battery fuses are provided and grouped together in the cabinet adjacent to battery box and protect the following:-

From left to right:-

F.1	-	Battery supply	-	Positive
F.2	-	Battery supply	-	Negative
F.3	-	Spare		

The fuses in each of these circuits are 60 amp fuses.

During preparation, the spare 60 amp fuses are to be tested in the following manner:-

1. Operate light switch to ensure light bulb functions.

2. Turn off light switch.

3. Lay fuse to be tested across the test block.

If the fuse is good the light should shine.

Fuse Tester

Three (3) auxiliary fuses - Positive, negative and spare are provided adjacent to the battery fuses and protect fuse test panels in the battery box and high tension compartment.

In the event of the fuse test light not functioning, check the globe is not defective and renew the defective fuse with the spare provided.

DRIVER'S DESK

It is located directly in front of the driver and is equipped with the following:-

1. Two air brake pressure gauges.
2. Flowmeter
3. Loadmeter (Ammeter)
4. Pan up buttons front and rear.
5. Pan down buttons front and rear.
6. Headlight switch (3 position).
7. Wheelslip/slide alarm - White light.
8. Brake cylinder pressure - Blue light.
9. Reset button.
10. Resistance fan failure - Amber light.
11. Resistance notch - Amber light.

Control Panel

1. Timetable light. 2. Blower motor switch. 3. Cab light.
4. Vigilance control button. 5. Demister. 6. Cab heater 1.
7. Cab heater 2

Observer's Panel

1. Power Fault light Red light.
2. Alternator failure Blue light.
3. Step light toggle switch.
4. Marker light.
5. Marker light.
6. Cab light.
7. Panel light.
8. Cab heater 1.
9. Cab heater 2.

In addition, windscreen washers and wiper controls are provided for both the driver's and observer's position.

Alarms and Safeguards

The locomotive is equipped with the following alarms and safeguards.

1. An alarm bell and buzzer are provided to warn the driver that one of the safeguards has operated.

2. Coloured lights indicating the various troubles that can occur in conjunction with the ringing of the alarm bell located at each driving position and are as follows:-

Power Fault Indicating Light (PFIL)

Red light and bell operates if any of the following occurs.

(a) Fault in traction circuit.
(b) Overcurrent in traction motors (straight overload operation 1400 amperes).
(c) Overcurrent on motor side of motor alternator (high tension).
(d) Opening of the control governor.
(e) Overvoltage relay tripped out (2050 volts).
(f) Failure in camshaft control to respond correctly.

Faults a, b, c, d cause the high speed breaker to open and this opens the line switches, which will also cause the blue light to shine.

Faults e, f, only cause line switches to open.

When the (PFIL) Red power fault indicator light operates under power return the accelerating handle or regenerating handle to the "OFF" position and press the fault reset button.

In the event of the motor alternator stopping the Blue Failed Alternator light (FAL) will also shine.
NOTE: There is a time delay of up to fifteen (15) seconds from the time the reset button is pressed until alarm ceases.

FAILED MOTOR ALTERNATOR (MA) SET

The blue light will shine and alarm bell will sound in the event of output from the motor alternator being lost.
In addition the blue light will shine and alarm bell sound in accordance with the following:-

(i) Motor alternator (AC) control circuit breaker tripped.
(ii) Battery charger circuit breaker (BACB) tripped.
(iii) Supply indicator circuit breaker (SIRB) tripped.
(iv) Main alternator supply breaker (ACB) tripped.

Under normal circumstances, the blue light and bell will be cancelled when output supply is restored by the resetting of the circuit breaker.

Motor Alternator (MA) Set Fails with both the Blue and Red Lights Shining and Alarm Bell Sounding

This indicates a fault on the high tension side of the motor alternator and the probable cause is the motor alternator overcurrent relay (MAOCR) has operated and tripped the high speed circuit breaker causing the line switches to open and isolating the 1500 volt overhead supply, which will stop the motor alternator.

To reset the motor alternator overcurrent relay (MAOCR) operate the fault reset button on the driver's control stand. This will cancel the red light and bell and immediately the motor alternator commences to produce current the blue light will be extinguished. A time delay of approximately fifteen (15) seconds applies.

Wheel Slip/Slide Indicator Light - White light and buzzer operates if either of the above occur.
When powering the armature current is reduced to the affected wheel and automatic notching stops until wheel slip is corrected. The tractive effort should be reduced by easing the accelerating handle toward minimum position in notch 4 as well as operating the sander button if continual slipping is experienced.

When operating in regeneration, the braking effort will be reduced to approximately 60% of the total value in accordance with the position of the regeneration handle on the unit affected until wheel slide is corrected.

When the wheel slip/slide occurs during pneumatic braking no automatic correction is effected and braking effort should be reduced in conjunction with sanding.

If continual wheel slip/slide is indicated a check must be made to ensure all wheels are capable of rotating freely. If not the unit must be isolated and considered a failure.

Brake Cylinder Pressure - Blue Light

The brake cylinder pressure blue light is provided to warn the Driver should the brakes inadvertently apply on the locomotive or on any trailing locomotive fitted with this switch in a multiple unit consist. The light is normally extinguished while ever the brakes are released.

When pressure in the brake cylinder rises to 30 kPa, the switch closes and the blue light shines. Upon the pressure, falling to 10 kPa, the switch opens, the blue light is extinguished.

The brake cylinder pressure blue light is train lined through the jumper coupling and will shine on all locomotives, when the brakes are applied on one or more of the locomotives in a multiple unit consist.

Should it be necessary to isolate the air brake on the No. 1 bogie for any reason, the brake cylinder pressure warning light becomes inoperative.

Brake Cylinder Pressure Blue Light Shines

The blue warning light will shine whenever the brakes are applied and pressure in the brake cylinders exceeds 30 kPa.

Should the blue warning light shine when the locomotive(s) are being operated with the brakes released, immediate action is to be taken to release the brakes in accordance with current instructions.

NOTE: This particularly applies in a multiple unit consist as severe damage can be caused to a trailing locomotive due to the brakes failing to release from a slight overcharge of the brake pipe.

Failed Resistance Blower Fan Alarm Amber light and bell.

Power circuit is interrupted automatically. The failed resistor blower light operates in the event of a failure of a fan or if any overheating of the starting resistances is detected by a thermal overheat device. Similarly, this also applies in the event of a traction motor blower failing.

Resistance notch indication Amber light.

This light shines on all units when the accelerating handle is opened and will continue to shine until all resistance is notched out of circuit by the automatic action of the camshaft. i.e. the light shines to indicate to the driver that resistance is in circuit and continuous operation of this light beyond a reasonable time period will require attention to determine the cause.

It is important to note that forward transition cannot be achieved while the amber light is shining with resistance remaining in circuit.

Thermal overheat device is a protective device and operates it any excessive overheating occurs within the starting resistances. The amber light shines, alarm bell sounds and power is interrupted.

MASTER CONTROLLER

The Reverse lever, Accelerating handle and Regenerative braking handle are assembled in the master controller.

1. Reverse Lever

The Reverse lever has four positions:-
Forward, Off, Reverse and Isolate.

Direction in which the locomotive moves is controlled by placing this lever in the desired position.

The Reverse lever should be moved ONLY when the locomotive is standing still.

The Reverse lever can only be inserted and removed from the master controller horizontally in the "Isolate" position.

The Reverse handle can be moved only when the accelerating handle and the Regenerative brake handle are placed in the "OFF" positions.

Removal of the Reverse lever locks the operating controls of the master controller.

When operating the locomotives in multiple unit, the Reverse lever should be removed from the master controller in all the cabs except the driving location.

The Reverse lever is also used for operating the interlock mechanism of the entrance door of the high tension compartment.

2. Accelerating Handle

The accelerating handle has six positions:-

OFF
POSITION NO. 1 (NOTCH DOWN)
POSITION NO. 2 (HOLD)
POSITION NO. 3 (NOTCH UP)
POSITION NO. 4 (RUN UP)
POSITION NO. 5 (TRANSITION)

The position of the accelerating handle is indicated by the illuminated indicating plate visible from the upper side of the master controller.

The powering motor current and the motor connection in powering is controlled by the operation of this handle.

The accelerating handle can be operated only when the Reverse lever is in Forward or Reverse position and the Regenerative braking handle in the "OFF" position.

Positions 1, 2, 3 are used for low speed operations and permit resistance to be inserted or deleted in "series" to achieve desired speed as follows:-

Position 1 (Notch down) When the accelerating handle is located in this position and returned to position 2 a bank of resistance is inserted in circuit.

Position 2 (Hold) This position is used when desired speed is achieved and during notching operation.

Position 3 (Notch Up) This position is used to achieve an increase in speed. By alternating the accelerating handle between position 3 and 2 positions the desired locomotive speed is attained. Each time the handle is placed in position 3 (notch up) and returned to position 2 (Hold) a bank of resistance is deleted. In this position when all resistance

is out of circuit and amber notching light is extinguished the weak field notches will be automatically inserted under the control Of the accelerating relay. A series of ten (10) starting resistances are provided therefore ten (10) separate notching movements can be made in the low speed notches.

Position 4 (Run Up) This is the normal operating position and gives the operator flexible control in each combination.

Position 5 (Transition) This position is used to achieve forward transition only when the notching light (amber) is extinguished and the accelerating handle is momentarily placed in this position transition is effected. The accelerating handle should then be placed in position 4 to give flexibility of control.

3. Regenerative Brake Handle

The Regenerative braking handle has two positions "OFF" and "REGENERATIVE BRAKE"

The Regenerative braking handle can be operated only when the Reverse lever is in the forward position and the accelerating handle is in the " OFF" position. There is a hump guide between the "Off" and the Regenerative brake positions.

The Regenerative braking effort is controlled according to the angle position of the regenerative braking handle.

The detailed function of the Regenerative brake is described under "Operating procedure".

Regeneration Brake Control

Regenerative braking can only be used if the reverser handle is in the forward position.

The braking range is set to provide maximum to minimum braking provided the current and weak field ratio limits are not exceeded to cause unstable traction motor operation.

The maximum armature current limit of 900 amperes in braking is gradually decreased to 690 amperes automatically during a time interval of ten (10) minutes to prevent over-heating of the traction motors. From the above it will be noted that the braking effort will be gradually reduced after the initial application even though the regenerative braking handle is in a fixed position.

The current limit is reset to 900 amperes by moving the regenerative handle to "OFF" position and back to regeneration zone.

Regenerative braking speeds are:-
Series - below 70 km/h.
Series-parallel - above 70 km/h.

Selection of either series or series-parallel under regenerative braking is automatically controlled and dependent on speed; up to 70 km/h series and above this speed series parallel combination. When speed falls below 70 km/h and regeneration was initiated in the series-parallel combination and braking is to continue, then series combination is to be selected. This is achieved by shutting off regenerative braking and then re-applying whilst travelling at the slower speed.

A voltage polarity detector (VPD) is provided to detect that the voltage of the armature circuit is higher than the overhead supply voltage before closing the line switches to commence braking.

MAIN ISOLATING SWITCH

It is necessary for this switch to be closed for any of the 1500 volt equipment to operate. The switch is interlocked with the doors of the high tension compartment so that the switch cannot be closed unless the doors are closed, and the doors cannot be opened unless the switch is open, and the equipment earthed.

The switch is unlocked by inserting the reverser handle in the "Power On" position.

Move reverser handle to "handwheel unlocked" position.

Turn handwheel through full movement in direction of arrows.

Move reverser key to "door unlocked" position and remove.

To lock door reverse above procedure.

Manual pantograph isolating switches are located inside the high tension compartment and enable individual pantographs to be isolated by the rotation of the spider wheel by opening a pantograph knife switch, isolating the pantograph from the rest of the locomotive.

JUMPER COUPLING

The locomotive is equipped with a permanently attached 42 pin jumper coupling and receptacle.

The 42 pin jumper coupling is removed from its dummy receptacle by turning a small wheel anti-clockwise to withdraw a threaded screw, thus releasing a locking clamp and freeing the jumper head.

When placing the jumper coupling in position its face must be located with the matching lugs in the receptacle. The locking clamp is then lifted upwards and secured in position with the small hand wheel being turned clockwise moving the threaded screw in to secure it.

These jumper couplings must be secured to the dummy receptacles and not left hanging loose as they are dangerous in this condition and can cause serious injury to personnel as well as damage to the equipment.

When removing and inserting jumper couplings Reverse handle should be located in "Isolate" position to reduce possibility of injury and burning of contact points.

The receptacle is fitted with a shear pin designed to permit the jumper coupling to be released and avoiding damage to equipment in the event of train being parted. Particular attention should be paid to the shear pin during preparation and if defective should be rectified prior to departing from the depot.

Jumper Wiring

Pin No.	Wire No.	Function
1	1	Forward
2	2	Reverse
3	3	Powering
4	4	Run UP
5	5	Regenerative Series-Parallel
6	6	" Brake
7	7	Transition
8	8	Fault
9		Spare
10	10	Overload, overcurrent and HB reset
11	11	Pan Up No. 2 end
12	12	Pan clown No. 2 end
13	13	Brake cylinder pressure indicator
14	CP	Control positive

Pin No.	Wire No.	Function
15	15	Pan Up No. 1 end
16	16	Pan Down No. 1 end
17	BN	Battery negative
18		Spare
19	CP	Control positive
20	20	Sanding control
21	20	" "
22	22	Compressor synchronising
23	CP	Control positive
24		Spare
25	CN	Control negative
26	CN	Control negative
27	27	Wheel slip
28	28	Remote supply
29	28	" "
30	RT/1	Regenerative brake pattern voltage
31	RN/1	Regenerative brake negative
32	CN	Control negative
33	VPN	Current pattern negative
34	BN	Battery negative
35	BN	" "
36	A	Notch advance
37	H	Notch hold
38	B	Notch back
39		Spare
40	40	Resistance notch indicator
41	VP1	Powering current demand
42	VP2	Regenerative brake demand

Note: No. 1 and 2 wires are crossed between junction boxes.

OVERLOAD RELAYS, DIFFERENTIAL CURRENT DETECTOR, HIGH SPEED BREAKER

High Speed Circuit Breaker is provided to interrupt overload and fault currents and will break the fault current very rapidly and greatly reduce the resultant arcing damage.

The High Speed Circuit Breaker is set to open when a fault or overload occurs in the circuit.

Overload Relays and Differential Current Detector

Differential Current Detector in case of a fault on the 1500 V equipment the locomotive is provided with overload and differential current relays which will trip the high speed breaker and open the line switches.

Overload Relays

The overload relays trip if the current flow to the traction motors exceeds 1400 amps.

The Differential Current Detector trips if the amount of current flowing into the circuit is different from the amount flowing out. This indicates an earth fault in the equipment.

Overload relays are reset by first returning the accelerating handle to the "off" position and then by pressing the fault "Reset" button on the driver's stand.

They should not be reset more than twice in quick succession. Repeated settings will damage the equipment and may result in a fire.

When the accelerating handle is in the open position the tripping of the overload relays and differential current detector is indicated by the presence of the Red Power Fault indicator light on the affected unit and the alarm bell on all units in multiple.

Overvoltage Relay

This relay is energised during regeneration and opens the line switches if the voltage which is being generated exceeds 2050 volts. It is reset by returning the regenerative handle to the "OFF" position.
Indication Red "Power Fault indicator" light on affected locomotive. Alarm bell on all units in multiple.

AUXILIARY RELAYS, AR 1 AND 2

Two auxiliary relays are mounted at each end of the locomotive adjacent to the respective "Pan up" and "Pan down" magnet valves.

An auxiliary relay (AR) must be energised before the no volt auxiliary relay (NVAR) will operate and energise the motor alternator contactor (MAC) and Compressor Contactor (CC) permitting these auxiliary machines to operate. At the same

time the fault alarm circuits also become operative when the "Pan up" button is pressed and Auxiliary relays (AR) energised.

When the "Pan down" button is pressed, the Auxiliary relays (AR) are de-energised, opening the motor alternator contactor (MAC) and Compressor Contactor (CC) before the Pantographs leave the overhead wire.

This ensures that current is not flowing from the overhead wire to the pantograph and prevents any arcing that may damage the pantograph strips or contact wire due to the auxiliary machines operating.
NOTE: When stabling both "Pan down" buttons must be pressed.

AIR COMPRESSORS

The air compressors are driven by 1500 Volt electric motors and are controlled in output by an electro pneumatic governor.

Air Compressor Control

For the air compressors to be running it is necessary for the compressor contactor circuit breaker on the circuit breaker panel and the compressor control switches in the electrical cabinet to be turned "ON" and high tension current available. Also the train control circuit breaker must be "ON"

The compressor control circuit is fed through the compressor motor circuit breaker and a compressor governor synchronising circuit breaker is also provided on the circuit breaker panel.

The compressors are under the direct control of the governor, which is of the square "D" type, located on the bulkhead of the machine compartment. Each compressor may be stopped and started through individual compressor switches in the low tension compartment behind the right hand door of the electrical cabinet. The compressor motors are protected individually by a high tension 20 amps fuse mounted on the panel in the high tension compartment.

One (1) spare compressor 20 amp fuse is provided for replacement Purposes.

PANTOGRAPH CONTROL

The pantographs are raised by main reservoir air pressure when available. If air pressure is not available a footpump is supplied at each end of the locomotive and after pressing "Pan up" button, or manually operating the "pan up" and AR set plungers of the respective magnet valve, the footpump should be operated until the pantograph makes contact with the overhead wire, the compressors commence to run and sufficient air is available to maintain contact between pantograph and contact wire.

In the air supply pipe line to the pantograph cylinders there is an isolating cock which is connected to the interlocking mechanism for the door of the high tension compartment. This cock is enclosed in the High Tension (H.T.) door interlock and prevents the pantographs being raised until the door is closed and locked.

A two position vented isolating cock is located at each end of the locomotive adjacent to the pantograph magnet valves which isolates the air supply to the respective pantograph roof cylinder when the handle is placed horizontally and is used to ensure the pantographs cannot be raised accidentally when running under dead sections of wiring.

TRACTION MOTOR BLOWERS

Two traction motor blowers are provided, one at each end of the machine compartment and are driven by 415 volt 3 phase power from the motor alternator (MA) set.

A toggle switch is provided in each cab on the driver's control stand to switch the traction motor blowers "on" and "off" These switches are connected in parallel and if one is left "on" in the trailing cab the traction motor blowers cannot be turned "OFF" at the driving location.

When operating in multiple unit consists a traction blower switch on each trailing unit must be left "ON" as there is no control through the jumper couplings.

Protection is incorporated in the traction motor and resistor blower fan motor circuits against overheating. If the fan motor contactors are not closed within sixty (60) seconds this is detected by interlocks on the contactors, the failed resistor blower fan amber light and alarm bell operates and power is automatically interrupted for a period of three minutes.

STARTING AND VERNIER RESISTANCES

A series of ten starting resistances are provided with suitable blower fans for cooling purposes. A thermal overheat device is provided in the resistance compartments to detect any excessive heating and operates in conjunction with a failed blower fan condition to cause an amber light to shine and alarm bell to sound.

In addition, under normal operation, the amber light will shine until the starting resistances are notched out of circuit. In multiple operation the amber light remains on in all units when any of the locomotives are powering with resistances in circuit.

Prevention of damage to the resistances by excessive heat is effected by the provision that if the resistance blower fan motors fail to start up within sixty (60) seconds, then the alarm circuit, amber light and bell is energised and power circuit interrupted for a period of three minutes.

Similarly, should the thermal overheat heat device operate, then the alarm circuit, amber light and bell, is energised and power circuit interrupted.

Under these circumstances it is necessary to wait until the resistances cool down and alarm ceases to function, which may take up to fifteen (15) minutes.

Control of Resistance Cooling Fan Motors

Resistance cooling fan motors cool the starting and vernier resistances. Thirty (30) seconds after power is applied Nos 1 and 2 cooling fans start. After a further five (5) seconds Nos 3 and 4 cooling fans start. If all resistances are cut out within thirty (30) seconds the fans do not start.

The cooling fans stop three minutes after power is removed from the starting and vernier resistances.

If any cooling fan contactors fail to close or resistor blower circuit breaker trips, the line switches are opened automatically within sixty (60) seconds and reapplication of power is stopped for three (3) minutes. The failed resistance blower fan amber light will shine and alarm bell will sound.

FAILURE OF TRACTION MOTOR BLOWERS OR RESISTANCE BLOWER FANS

In the event of the failure of a traction motor blowers or resistance blower fans the locomotive can only be operated as a light engine using the low speed notches (1 to 3) and full series only is available. Notching through resistances must be completed within sixty seconds with a maximum of 400 amperes per motor during notching.

When operating under above conditions the following motor currents should be observed.

150 amperes per motor continuous
230 amperes per motor for 25 minutes
270 amperes per motor for 15 minutes

If operation cannot be achieved without exceeding above amperages a relief locomotive must be obtained.

Regenerative braking is not available under these conditions.

WHEEL SLIP AND SLIDE CORRECTION

This function is entirely automatic. Wheel slip and slide is detected by generators provided on each axle. These speed and acceleration differences will be detected by the control system and correction will be made by reduction of current to the traction motor of the slipping wheel set only.

If the driver receives continued wheel slip indications he should reduce the current to a level where only occasional wheel slip conditions occur.

If wheel slip exists for more than two (2) seconds while operating in resistance notches the main resistance camshaft will automatically move backwards one notch.

Wheel Slide Protection in Regenerative Brake

If a wheel slide occurs in regenerative braking the braking current is reduced to approximately sixty percent of that value set by the position of the regenerative braking handle. After wheel slide is corrected the braking current is restored to the value at which the regenerative handle is set.

Demisters

Electric demisters are provided in each cab and supplied with 120 volt DC power through a Demister circuit breaker on the circuit breaker panel and controlled by a toggle switch on the driver's panel in each cab.

Hotplate

A hotplate is provided in each cab supplied with 240 volt AC power and each controlled by a three position rotary switch. Each hotplate is fed through separate circuit breakers on the circuit breaker panel.

Headlights

Twin sealed beam headlights are Provided at each end and fed from 240 volt AC power Supply via headlight circuit breakers located on circuit breaker panel. Each pair of headlights is controlled by a three position switch located on the driver's console in each cab. Circuit breakers are also provided for the high and low beam circuits, located below circuit breaker panel.

Cab Refrigerator

Each cab is fitted with a refrigerator which is of simple design and uses air at high pressure for cooling under thermostatic control.

The cabinet is a top loading type and has a capacity of holding a water bottle and a supply of foodstuffs which may require to be kept cool.

It is the utmost importance that enginemen keep the refrigerator in a clean and hygienic condition at all times and do not place items of an odorous nature in them.

The air supply to the refrigerator passes through a two position isolating cock, which is open in the vertical position and closed in the horizontal position. The cock is located on the rear panel of the cabinet.

The air demands for the operation of the refrigerators is high and to ensure sufficient air supply is available for other essential equipment on the locomotive, it is essential that before vacating the cab, Enginemen close off the air supply to the refrigerator by placing the two position isolating cock in the horizontal position and ensure that only one refrigerator is in use at any time.

AIR CONDITIONING

Air conditioning is provided in both locomotive cabs with 415 V AC power supplied from the motor alternator (MA) set.

To avoid wear, the air conditioning unit in unoccupied cabs should be switched off.

Each air conditioning system consists of two separate units, the compressor condenser unit and evaporator unit. The compressor condenser units are mounted on the right hand wall of the locomotive at both ends and contain the circuit breakers for each unit. The evaporative unit contains the air circulating fan, cooling coil, heaters, thermostats and selector switch. A main air conditioning circuit breaker is located below the circuit breaker panel.

A test key switch is provided for maintenance purposes.

The selector switch is located above the Driver's seat just below roof level and is labelled:-

Heat High, Heat Low, Off, Auto, Cool, Vent.

Should the MA set fail the air conditioning will be inoperative.

Air nozzles are located below roof level towards the front of the cab and can be used to direct the flow of air by both the Driver and observer.

Cab heating is best achieved by using the individual cab heaters in front of the Driver and Observer in conjunction with the heaters in the air conditioning unit.

The heaters in each cab are supplied with 240 volt A.C. power through cab heater circuit breakers located on circuit breaker panel. Each heater is controlled through a High - Low switch on the respective consoles.

VIGILANCE CONTROL EQUIPMENT

The vigilance control equipment fitted is the E.H. type with a solid state timing unit controlling a penalty application magnet valve which upon being de-energised will exhaust brake pipe pressure to atmosphere, i.e., the system is fail safe.

All current instructions applicable to both normal and emergency working procedures for the E.H. type vigilance control will apply.

Battery Switch

Before opening, close both Driver's brake valve isolating cocks. Vigilance control penalty valve when de-energised will dump brake pipe pressure.

This action is necessary to ensure the vigilance control is isolated by closure of the isolating cocks before the electrical circuit to the penalty magnet valve is interrupted by opening the battery switch.

ISOLATING COCKS

Below the Footplates

1. Two main reservoir pipe cocks at each end of the locomotive.

2. One brake pipe cock at each end of the locomotive.

3. Two sets of independent application and release cocks at each end of the locomotive.

4. Two brake cylinder isolating cocks, left side.

5. Main reservoir isolating cock, left side.

In the Cab

1. Brake valve cut off valves, one on each brake pedestal.

2. Brake pipe emergency cock adjacent to the brake pedestal.

3. M.U. valves for isolating independent brake, one on each brake pedestal.

4. Refrigerator isolating cock, on side panel of refrigerator in each cab.

5. A small compartment is provided adjacent to the hotplate in which the following are located:-

   (i) Horn
   (ii) Windscreen wipers and washers
   (iii) No. 2 end. An additional isolating cock is provided for the above equipment.

In the Engine Room

Bulkhead behind No. 1 Cab.

1. Pantograph isolating cock No. 1 end.
2. Horn change-over cock.
3. High Tension door interlock.
4. Vigilance control emergency application valve.
5. Control air reservoir.
6. Compressor governor.
7. Control valve on brake equipment stand isolates locomotive automatic brake.
8. Dead locomotive device on brake equipment stand.
9. Two sanding magnet valves, right side engine room wall.
10. Pantograph isolating cock, No. 2 end.

NOTE: The control valve isolating cock is located on the brake pipe and when closed, only isolates the automatic portion of the brake, i.e., the independent brake is operative with the isolating cock closed.

CIRCUIT BREAKERS AND SWITCHES

The following circuit breakers are provided on the circuit breaker panel and protect the various circuits on the locomotive in accordance with the following:-

1.	Battery Charger (BACB)	- Battery charger, supply indicator circuit breaker (SIRB) and supply Indicating relay.
2.	Motor alternator control (MACB)	- Motor alternator control circuits.
3.	Motor alternator output (ACB)	- Motor alternator output.
4.	Traction motor blower (MBB1) (MBB2)	- Traction motor blower circuits.

5. Resistor Blower motor (RBB11) (RBB12) (RBB21) (RBB22) - Resistance blower fan motor circuits.
6. Pilot Motor Control (PMB) - Main supply to the master controllers and camshaft pilot motors.
7. Blower motor control (BMCB) - Traction motor and resistance fan blowers control circuit.
8. Train control (TCB) - Motor alternator contactor for supply to motor alternator (MA) set, Compressor Control Circuit and control positive through the reverser contacts.
9. Pantograph Control (PCB) - Pan up, Pan down and auxiliary relays set and trip coils. Motor alternator and compressor operation.
10. Control circuit (main) (CCB) - Traction control circuits.
11. Control positive (CPB) - Master Controller supply through the control governor and regenerative brake control. Sanding magnet and reset buttons through reverser contacts.
12. Regenerative brake control (RBC) - Regenerative brake control circuits.
13. Vigilance Control (VCB) - Vigilance control circuits.
14. Headlight (HLB) - Headlight Circuit
    (HLBB) - Hdlight bright)below circuit
    (HLBD) - Hdlight dim)breaker panel
15. Heater (CHB1) - Cab heater No.1 end.
    (CHB2) - Cab heater No.2 end.
16. Demister (DB) - Demister circuit.
17. Hotplate (HPB1) - Hotplate No.1 end.
    (HPB2) - Hotplate No-2 end.
18. Compressor Control (CMCB) - Compressor control circuits, both compressors.
19. Compressor Synchronise (CSB) - Compressor synchronising circuit.

20. Fault Breaker (FB) - Fault, lights, bell and buzzer.

21. Lighting Control 1) (LCB) - No.1 end lights - cab, timetable, coupler, steps, number, marker and panel.

22. Lighting Control 2) (LCB) - No.2 end lights - cab, timetable, coupler, steps, number, marker, panel and toilet.

23. -

24. -

25. Machine room lights (MRLB) - Machine room lights and high tension compartment lights.

26. Supply Indicator Relay (SIRB) - Operates blue light and bell to indicate loss of motor alternator (AC) supply. Alarm also operates in the event of this circuit breaker tripping

27. Remote supply (RSB) (sealed open) - Completes circuit from the source of supply on another locomotive in the case of flat batteries.

28. Main air conditioning supply - Supply to both air conditioning units - below circuit breaker panel

Electrical Cupboard	Machine compartment Function
Compressor control switch (CMS1)	No. 1 Compressor control.
Compressor control switch (CMS2)	No. 2 Compressor control.
Control circuit cut out switch (CCOS)	Power control circuits.
Sequence test switch (SQ TEST SWITCH)	Testing control circuits.

PREPARATION

1. In the event of any equipment being found "cut out" unless labelled "Not to be used", or in the absence of a relevant entry in the Log Book, such equipment must be "Cut In".

2. If any authorised employee be at work on an electric locomotive at the time when the driver arrives to commence testing operations, and if such work is likely to affect the electrical or air equipment, the driver must not proceed with the testing operations on the locomotive concerned, or cause the locomotive to be moved, until the work has been

completed and all danger discs removed from the departure end of the locomotives.

3. When an electric locomotive is stabled at a depot, the procedure outlined for stabling must be carried out by the stabling driver, unless instructed not to do so by the Shed Chargeman.

Preparation

Obtain Driver's Daily Report Sheet and Reverser handle. On arrival at locomotive peruse Log Book and commence preparation at No. 1 end.

No. 1 Cab

The following items are to be checked:-

1. Hand brake is applied.

2. Check the accelerating handle, regenerative handle are in "off", Reverse lever in "Isolate", and removed.

3. Driver's brake valve cut off in "OUT" MU2A valve in "Dead" position.

4. All switches on driver's and observer's consoles not required are up and off.

Proceed to machine compartment
Check

(a) Circuit breaker panel left wall.

(b) Check ammeter for accuracy of zero reading.

(c) Close battery switch.

(d) Supply Indicating switch (S.I.S.) "ON".

(e) All circuit breakers up and on except remote supply (RSB) which is sealed in the open position.

(f) Check spare globes supply in adjacent rack.

Check air cocks on bulkhead behind No. 1 cab.
Vigilance control sealed and all air cocks properly positioned.
Check fire extinguishers in machine compartment during preparation for charge and check seal
Sander magnet valve isolating cocks (R wall).

Check electrical cupboard (through small door):-

(a) Control cut out switch (CCOS) is in "ON" position.

(b) sequence test switch is in 'normal'.

(c) Compressor motor rotary switches (CM 1 and 2) are in "ON" position.

Warning. Enginemen are warned against opening the electrical cupboard as 240 volt electrical current is present. On no account are the doors to be opened while the pantograph is in the raised position or motor alternator operating.

Check sanding magnet valve isolating cocks open (R wall).
Check brake control valve and dead engine cocks correctly positioned, located under traction motor blower No. 1 end.
Operate reverser handle in high tension door interlock.
Check high tension fuses are in position and spare fuses:-
1 x 20 ampere H.T. fuse (compressor).
1 x 10 ampere (no volt relay, polarity detector).
Check manual pantograph isolating switches are correctly located.
Ensure high tension door interlock properly locked.
Check motor alternator circuit breaker (ACB) is in "ON" position on right wall adjacent to traction motor blower No. 2 end.

No. 2 end

(a) Driver's brake valve cut out valve in "OUT".
MU2A valve in "dead".

(b) All switches on driver's and observer's consoles not required are turned "off".

(c) Insert reverser handle in "Isolate" position and move to "Off" position (centre).

(d) Press pantograph raise button.
If no main reservoir pressure is available the pantograph is raised by using a footpump (one each end of the locomotive).
In case of insufficient main reservoir air pressure the alarm bell will sound and the Red Power fault light (PFL) will shine because the high speed breaker will not close until 485 kPa pressure is attained. The Blue Failed Alternator light (FAL) will also shine.

(e) Check line voltage is normal (1100-1500 V DC)
Note: If the line voltage is less than 110OV the high tension machines will not operate.

When 485 kPa Control air pressure is available return reverser handle to "OFF". Press Overload reset button (ORB) which should cause high speed breaker to close, Red Power Fault light and Blue Failed Alternator light to be extinguished, also alarm bell to cease sounding.

When the motor alternator commences to run 415V 50HZ three phase power will be fed to the control and auxiliary circuits.

With main reservoir fully charged to 700-800 kPa open brake valve cut off cock and MU2A valve and test brake as follows:-

1. The independent brake valve is to be in the 'application' position and the automatic brake valve in the 'release' position. The brake valve cut off valve set at 'IN' and MU valve in the 'lead or dead' position on the brake pedestal being tested.

2. Check the main reservoir, brake pipe and equalising reservoir pressures. The brake pipe and equalising reservoir pressure should be 500 kPa. The main reservoir pressure 700 to 800 kPa.

3. Place the independent brake valve in the 'release' position and depress the vigilance control acknowledgment button. The flashing light is to be acknowledged, whilst the brake test is being carried out.

4. Place the automatic brake valve in the minimum reduction position and note that a minimum reduction of 50 kPa takes place in the equalising reservoir and brake pipe pressures. The brake cylinder pressure should rise to between 70 and 105 kPa.

5. Release the engine brakes with the independent brake by depressing the handle in the 'release' position until a full release of brake cylinder pressure is obtained.

6. Place the auto brake valve in the 'service application' zone and reduce the equalising reservoir and brake pipe pressure by 70 kPa. Note that the regulating and relay valves function and the brake cylinder pressure increases.

7. Conduct a power and sand test. Place brake valve cut off valve in the 'out' position, check the brake piston travel is within required limits and sands are working correctly. Note that the brake pipe pressure has not seriously reduced or increased with the brake valve cut off valve set in the 'out' position.

8. Regenerative Brake Test. Place the reverser in the 'forward' position, and set brake valve cut off valve in the 'in' position. Move the regenerative handle to the braking position. Note that minimum brake cylinder pressure releases. When the brake cylinder pressure has released, reduce the brake pipe pressure to below 250 kPa. Note that the locomotive brakes re-apply. Move the regenerative handle to the 'off' position.

9. Place the automatic brake valve handle in the 'release' position. Note the brake pipe and equalising reservoir pressure is restored and the locomotive brakes release.

10. Move the accelerating handle to position 3 and back to position 2. Note the load meter (ammeter) reading indicating that the pneumatic control switch has closed. Fully apply the independent brake and check the brake cylinder pressure rises to 325 kPa. Move the accelerating handle to the 'off' position.

11. Place the automatic brake valve in the emergency application position. Note that a heavy reduction occurs in the brake pipe and equalising reservoir pressure.

12. Move the automatic brake valve handle to the 'release' position and note that the flow meter functions correctly.

13. Place the independent brake valve handle in the 'release' position without depressing handle and note that the brake cylinder pressure releases.

14. Open emergency cock at base of pedestal and check that brake pipe is quickly and considerably reduced in pressure.

15. Maintaining feature check

    Close emergency cock and fully recharge brake pipe.

    Place auto brake valve handle in service zone and reduce brake pipe pressure by 70 kPa. Leave handle in this position.

    Open emergency cock slightly to vent brake pipe and note that brake pipe pressure remains constant at the reduced level.

16. While the brake test is being conducted, the cutting in and out point of the governor is to be checked.

Raise and lower pantographs to ensure correct operation.
Set switches as required.
Isolate brake equipment.
Place reverser handle in "Isolate" and remove.

Alight from locomotive cab on driver's side.

- Examine front of locomotive, checking all air cocks are closed and air hoses properly secured to dummy couplers. Check automatic coupling in good condition and operates correctly also jumper coupling in good condition and properly secured.

- Pass down the side of the locomotive, examine brake shoes and rigging, springs etc. Check that brake cylinder isolating cocks are open, sands flow adequate and sandpipes set to rail, main reservoir isolating cock open, compressor oil level checked by lifting filler cap, main reservoirs are fitted with self draining valves.
- Enter cab at No. 1 end, carry out instructions as previously detailed in No. 2 cab, lower and raise pantographs to ensure correct operation. Lower leading pantograph if it is not required.
- Set required tail and number lights.

Alight from locomotive on driver's side.

- Pass along locomotive checking as previously and including battery box and condition of spare fuses.
- Check red flags, detonator headlights, windscreen washers, wipers, marker gauge and interior lights.
- At departure end, set up for operation and release hand brakes.

OPERATION PROCEDURE

Acceleration in Series

When starting from rest the "Accelerating Handle" is moved from "OFF" and should be operated between "Notch 3" and "Notch 2" (Hold) which advances the "Resistance Cam Switch" one step at a time until drawgear slack is taken up. In the Manual Advance (Notch 3) maximum current of 1100 amperes (for 10 seconds) is available if required providing adhesion will permit. The "Accelerating Handle" can be located in Notch 4 in the lowest position when the locomotive will automatically notch through to the Full Series Weak Field. By advancing the "Accelerating Handle" in Notch 4 zone (towards Notch 5) acceleration can be increased within the adhesion limits up to the maximum of 900 amperes accelerating current for 5 minutes.

While operating in Notch 4 if a reduction in speed is required, the "Accelerating Handle" is returned to minimum which will reduce the current to the traction motors. If a further reduction in speed is required, the "Accelerating Handle" is moved back to Notch 1 (Notch down) and returned to Notch 2 (Hold). Adopting this method manually notching backward one step at a time controlling current to the traction motors can be achieved.

Transition from Series to Series-Parallel

If a further increase in speed is required providing the resistance notch light is not illuminated the "Accelerating Handle" is momentarily placed in Notch 5 (Transition) and returned to Notch 4 causing the transition to Series-Parallel combination, automatic notching occurs through to Series Parallel Weak Field. Using the "Accelerating Handle" in this zone, accelerating current can be varied from 340 amperes to 900 amperes thus enabling the driver to control his accelerating rate. While operating in Notch 4 if a reduction in speed is required the "Accelerating Handle" can be moved back, thereby reducing the current to the traction motors.

Transition from Series-Parallel to Parallel

If a further increase in speed is required whilst operating in Series-Parallel the "Accelerating Handle" is momentarily placed in Notch 5 (Transition) and returned to Notch 4 causing transition to the Parallel combination (providing resistance notch light is extinguished). Once again automatic notching will occur through to Weak Field and by varying the "Accelerating Handle" position, acceleration current can be controlled between 340 amperes to 900 amperes.

While operating in Notch 4 if a reduction in speed is required, the "Accelerating Handle" can be moved back thereby reducing the current to the traction motors.

Speed Reduction

If a speed reduction is required, return accelerating handle to the "OFF" position until desired reduction in speed is achieved then return the accelerating handle to the appropriate position e.g.,

Note. There is no backward transition as on a 46 class locomotive.

If a speed reduction is required from series-parallel or parallel combinations the accelerating handle is returned to "OFF"

position and then placed in Position 4 where the locomotive will keep notching automatically to maximum series weak field position. If the obtainable speed in this combination is not sufficient, series-parallel combination is selected by moving the accelerating handle to Position 5 momentarily from "OFF" position (providing the Resistance Notch light is extinguished) the control circuit will be established and transition effected. This manoeuvre is repeated if a higher combination to Parallel is required.

Shunting and Low Speed Control in Series Combination

From the "OFF" position advance the accelerating handle to Notch 3 which moves the resistance camshaft one step forward. The handle is operated between Notch 2 (Hold) and Notch 3 (Notch up) until the desired speed is obtained when the handle is maintained in Notch 2 (Hold).

If a reduction in speed is required the accelerating handle is returned to Notch 1 (Notch down) and back to Notch 2 (Hold) which moves the resistance camshaft one step backward.

This is repeated until the desired reduction in speed is achieved.

Operating through Water

Under no circumstances should the locomotive be operated through water that is deeper than 100 millimetres above rail level and speed must not exceed 3 kilometres per hour.

Operation over points and crossovers

When operating the locomotive at speeds in excess of 40 km/h reduce the motoring current by returning the accelerating handle to the minimum current position in Notch 4 seven seconds before the locomotive reaches a railroad crossing or points.

When operating in regenerative braking reduce the regenerative handle to minimum position as above.

This action is required to minimise brush bounce and thereby reduces fusion damage between the carbon brushes and commutators of the traction motors.

REGENERATIVE BRAKE CIRCUIT

There are two stages of regenerative braking. The six (6) traction motor armatures are either connected in series or in Series-parallel with 3 motors in series in each group. The six traction motor fields are separated from the high tension circuit and connected in series in both stages. The fields are supplied by means of an exciter rectifier and step down transformer from the 415 V auxiliary supply from the motor alternator (MA) set.

The amount of regenerative braking is controlled by variation of the traction motor field current.

Regeneration Brake Control

Regenerative braking can only be obtained if the reverser handle is in the forward position.

The braking range is set to provide maximum to minimum braking provided the current and weak field ratio limits are not exceeded to cause unstable traction motor operation.

The maximum armature current limit of 900 amperes in braking is gradually decreased to 690 amperes automatically during a time interval of ten (10) minutes to prevent overheating of the traction motors. From the above it will be noted that the braking effort may be gradually reduced after the initial application even though the regenerative braking handle is in a fixed position.

The current limit is reset to 900 amperes by moving the braking handle to "OFF" position and then returning it to the braking zone.

When the speed is more than 70 km/h braking occurs within the series-parallel combination automatically. When the speed is more than 30 km/h and between 70 km/h series combination is selected automatically. In the event of the braking combination needing to be changed the regenerative braking handle is to be returned to the OFF position and braking will then be established upon the opening of the regenerative braking handle in the correct combination.

A voltage polarity detector (VPD) is provided to detect that the voltage of the armature circuit is slightly higher than the overhead supply voltage before closing the line switches to commence braking.

LOSS OF OVERHEAD POWER

Loss of overhead power to a locomotive can arise from two possible causes, namely:-

(i) A fault within the electrical equipment of the electric rolling stock.

(ii) Loss of supply to the overhead wiring caused by an overhead wiring fault or by loss of supply to a sub-station.

Electric Locomotives - Single Units

(i) As soon as possible after the initial loss of power, return the accelerating handle to the "off" position and if using regenerative brake, the regenerative handle to the "off" position. Avoid stopping with any portion of the train on a bridge, viaduct, catch-points, crossing or in a tunnel, under an air gap, or any position likely to obstruct trains on another line.

(ii) If supply is not available two minutes after the initial loss of power, the driver should switch off motor generators and compressors, lower pantographs, observe that they are lowered and charge storage reservoir.

(iii) Four minutes after the initial loss of power the driver should raise one pantograph and arrange to have it carefully observed when it makes contact with the overhead wire.

(iv) If a flash occurs and power goes off immediately, as indicated by the line voltmeter in the driver's cabin. It is probable that there is a fault on the locomotive. If such is the case, the pantograph should be lowered and arrangements made for a relief locomotive to be obtained.

(v) If power is restored and remains restored, proceed.

(vi) If there is no flash at the pantograph and power is not restored the pantograph should be lowered.

(vii) The pantograph should be raised after a further period of two minutes for a similar test. If there is no indication of return of power it should be lowered again. The observer should then be sent to communicate with the nearest signal-box.

(viii) The driver should act on instructions received from the Signalman and, unless he has definite knowledge that his locomotive is defective, he should raise a pantograph every five minutes to test for the return of power and lower it if power has not been restored.

(ix) He should make arrangements for the securing and protection of the train as required in accordance with the regulations.

Electric Locomotives - Multiple Unit

In the case of electric locomotives in multiple unit consists, the driver should carry out the instructions detailed above for single unit electric locomotives except that operation (iii) should be applied to one pantograph of the leading locomotive, and operation (vii) to one pantograph of the trailing locomotive.

Protection of Train

The train crew must make arrangements for protection of the train where required in accordance with the provisions of Rule No.243, 244 or 245 where applicable.

Loss of Overhead Power on Heavy Gradients

If overhead power is lost when a train is ascending or descending a heavy gradient an immediate application of the automatic air brake is to be made to stop the train which is then to be secured by the application of sufficient hand brakes to hold it stationary on the grade and the automatic brake released. This instruction must be observed at all times, as it is essential that the train be brought to a stand before main reservoir pressure has been depleted. When power is restored, full main reservoir pressure must be obtained before the hand brakes are released.

PANTOGRAPHS

Most wear on the overhead wire is caused by passage of current to the pantograph strips rather than by friction between wire and strips. It is therefore desirable at all times when hauling a train to operate with both pantographs raised. The current density at the pantograph strips is thereby kept as low as possible and the rate of wear on the overhead wire kept as low as possible.

The number of pantographs to be raised is summarised below:-

Location Between places stated	Number of pantographs to be raised on each locomotive			
	Metropolitan Area generally	Rhodes and Gosford Liverpool and Glenlee	Nepean River Bridge and Katoomba	Katoomba and Lithgow
Light Engines				
one, two or three locomotives (d)	1	1	1	1
Hauling Trains				
single locomotives any speed	2	2	2	2
Two units coupled				
below 90 km/h	1	2	2	2
above 90 km/h	1	1	(a)	(a)
Three units coupled				
any speed (c)	1	1	2	1(b)

NOTES: The rear pantograph should normally be raised where only one is permitted.

(a) Speed not to exceed 90 km/h on this section.

(b) Two pantographs should be raised on each locomotive between Lithgow and Bell only in the up direction.

(c) Locomotives must not be operated in parallel.

(d) Light locomotives may run at normal track speed.

(e) To comply with these instructions, it will be necessary for drivers of coupled electric locomotives to raise and lower the pantographs, if necessary, when passing the following points:-

West: Penrith - Katoomba - Bell (up only)

North: Rhodes

South: Liverpool

North Shore: Hornsby

(f) Pantographs may be raised or lowered with the locomotive(s) in motion, providing the accelerating handle is first moved to the off position. It is important to ensure at all times that pantographs are in the fully raised or lowered position, to avoid damage to overhead equipment.

MULTIPLE UNIT OPERATION

These locomotives can only operate with other 85 class locomotives in a multiple unit consist. At all other times, should it be necessary to operate with locomotives of different types then both units must be manned.

When operating with multiple units, the normal practice is for all locomotives to have the jumper couplings inserted between them, thus providing for control of all locomotives from the leading driver's cabin.

The locomotives are to be prepared as described in preparation duties.

Each locomotive is equipped with a 42 pin jumper coupling at each end and suitable air hose couplings. When the locomotives are coupled for multiple unit operation, one jumper coupling is to be connected between the locomotives. The brake pipe and main reservoir, No. 3 control and No. 4 independent release air hoses are to be coupled and all relative air hose cocks opened.

Control and Brake Valve Handles

When operating with units in multiple unit consists, reverser handle, automatic brake valve handle, and the independent brake valve handle should be in position on the appropriate equipment in the leading driver's cabin.

In all other cabs in the locomotive consist the reverser must be removed from the control stands in "Isolate" position. Brake equipment cut out in accordance with instructions and motor alternator switch left "ON".

CHANGING OPERATING STATIONS

The following procedure is to be adopted when changing operating stations.

1. Fully apply the independent brake and place M.U. valve in the trail position. Move the independent brake valve handle to the release position, without depressing it and remove the handle.

2. Reduce the brake pipe pressure by making a 150 kPa brake pipe reduction with the automatic brake valve and place the brake valve cut off valve in the "out" position. Move the automatic brake valve handle to the "handle out" position.

3. The accelerating and regenerative brake handles are to be in the "off" position and the reverser handle placed in the isolate position and removed. The motor alternator will stop when the reverser handle is moved to the "Isolate" position.

4. The traction motor blower switch is to be turned "off".

5. The driver is to remain at the control stand being vacated with the automatic brake valve in the "handle out" position.

6. The observer is to proceed to the stand being cut in, fully apply the hand brake, insert the independent brake valve handle, place the M.U. valve in the "lead or dead" position, release and fully apply the brakes.

7. The driver is to observe that the brakes have released and applied and not less than 285 kPa is indicated on the brake cylinder gauge, and remove the automatic brake valve handle.

8. Proceed to the control stand being cut in with the automatic brake valve and reverser handle, insert the reverser handle and place the brake valve cut off valve at the "in" position.

9. The brakes are to be tested in the normal manner and the observer is to release the hand brake under the driver's supervision.

10. Move the reverser handle from the isolate position, turn on the traction motor blower switch and press the fault reset button to restart the motor alternator. The failed alternator blue light and bell will operate for approximately thirty (30) seconds due to it being necessary for the alternator output to exceed a predetermined voltage before the alarm ceases.

Note: When the reverser handle is moved to the isolate position, the high speed circuit breaker trips and opens the line switches, which stops the alternator.

AMALGAMATION AND DIVISION OF UNITS

Multiple Unit Operation

Instructions and Amalgamation

85 class electric locomotives may be operated in multiple unit consists of two, three and four with their own type. When operating in combination with other units all locomotive types must be manned.

Coupling of Units for Multiple Unit Operation

1. When the unit is prepared, place in position and secure with the independent brake in the application position, hand brake to be applied.

2. (a) Note the brake pipe and brake cylinder pressure.

   (b) Accelerating and Regenerative brake handles to be in the 'off' position.

   (c) Move the reverser handle to the 'isolate' position.

3. On trailing unit:-

   (a) Move the trailing unit onto the leading unit and engage the automatic couplings. Test pull to ensure that they are properly coupled. Secure the automatic coupling locking catch in position.

   (b) Reduce the brake pipe pressure to 350 kPa and place brake valve cut off valve in the 'out' position.

   (c) Reduce the brake cylinder pressure to 150 kPa.

   (d) Remove the automatic brake valve handle in the 'Handle out' position. Place the M.U. valve in the 'trail' position and remove the independent brake valve handle in the release position.

(e) (i) Accelerating and Regenerative brake handles to be in the 'off' position.

(ii) Place the reverser handle in the 'isolate' position and remove.

4. Couple the brake pipe, main reservoir, No. 3 control and No. 4 Independent release air hoses and open the associated cocks.

5. Note that the brake pipe and brake cylinder pressures build up on the air gauges to the same setting as on the leading unit.

6. Supervise the insertion of the jumper coupling.

7. The reverser and brake valve handles are to be suitably located in the No. 1 end driver's cab.

8. On leading unit:-

(a) Test the operation of the pantographs.

(b) A check is to be made between the units to ensure that there is no leakage on the air hose connections.

(c) Release the hand brake.

(d) Move the reverser handle from the isolate position, with the traction motor blower switch on, press the fault reset button to restart the motor alternator.

(e) Proceed with normal operation.

Coupling for Multiple Unit Working - Observer's Duties

1. Upon preparing to couple the units, open and centre the automatic couplers to ensure they engage when brought together.

2. When the automatic couplers are brought together, wait until the driver test pulls the couplings to make sure that they are properly engaged. Then secure the automatic coupling locking latch in position.

3. Couple up the brake pipe, main reservoir and one set of independent brake air hoses.

4. When driver signals, open the air hose cocks between the units.

5. Ensure the jumper head is inserted correctly.
   When inserting the jumper coupling, make sure of a firm footing. Also examine the jumper coupling pins to ensure they are not bent or damaged.

NOTE: In all cases where time is allowed for the turning of units and piloting locomotives to whistling out point, such duties must be performed by the observer.

MULTIPLE UNIT OPERATION - DIVISION OF UNITS

When units are being divided in multiple unit working either in depots or at stations enroute to suit traffic requirements, the following procedure is to be adopted:-

1. When the locomotives have been brought to a stand, they are to be secured with a full application of the independent brake and hand brakes are to be applied.

2. The observer is to remove the jumper coupling and secure it in the dummy receptacle.
   Close the brake pipe, main reservoir and independent brake pipe air hose cocks and uncouple the air hoses.

3. On the Trailing Unit:-
   Place the automatic and independent brake valve handles in position. Move the M.U. valve to the 'lead or dead' position and fully apply the independent brake. Place the brake valve cut off valve at the "in" position and move the automatic brake valve handle to the release position.

4. The observer will then ease the Driver up, disengage the automatic couplers and attach air hoses to the dummy couplers.

5. Two wooden chocks are to be located on each side of the No. 2 wheel of the stationary locomotive.

6. On leading locomotive, proceed with normal operation.

STABLING

When the locomotive has been brought to a stand at the point of stabling the following duties should be carried out.

1. Fully apply the independent brake and place M.U. valve in the trail position. Move the independent brake valve handle to the release position, without depressing it, and remove the handle.

2. Reduce the brake pipe pressure by making a 150 kPa brake pipe reduction with the automatic brake valve and place the brake valve cut off valve in the 'out' position. Move the automatic brake valve handle to the "Handle out" position.

3. The accelerating handle is to be in the 'off' position, the Regenerative handle in the 'off' position, the reverser handle placed in the 'Isolate" position and removed.

4. Press Pan down buttons to lower pantographs.

5. When leaving locomotive, open battery switch, close all windows and doors.

6. Remove the reverser handle in isolate position. Enter all defects in the log book.

7. Chocks to be placed each side of No. 2 wheels.

POSITIONING OF CONTROLS FOR HAULAGE OF DEAD LOCOMOTIVES

Should a locomotive fail and be left at a station, the qualified Driver, prior to leaving the unit must secure the locomotive by means of the hand brake and carry out normal stabling duties and leave the unit in order vide instructions relating to the haulage of the unit.

An electric locomotive of any type when required to be hauled dead must not be attached to a train unless a qualified Mechanical and Electrical Equipment Branch Technical Officer or Technician has certified to its fitness to be hauled. Where possible a Driver required to haul a 'dead' locomotive, should contact the District Manager, Locomotives and Rolling Stock or other Technical Officer nominated, for clearance to do so.

The following procedure is to be adopted on the 'dead' locomotive:-

1. Under normal operating conditions when the No. 3 control and No. 4 independent release air hoses can be satisfactorily coupled for multiple unit air brake operation.

   (a) Air brake equipment is to be set up for normal multiple unit operation.

   (b) Accelerating Handle in the 'off' position, reverser handle removed and regenerative handle in the 'off' position, where provided.

(c) All switches and circuit breakers on the control stand and control panel to be placed in the 'off' position. Battery switch open.

(d) Reverser switch, where provided, to be located in the "isolate" position.

(e) Main reservoir, brake pipe, No. 3 control and No. 4 independent release air hoses are to be coupled between the locomotives and associated air cocks opened.

(f) The brakes must be operative on the dead locomotive.

2. When the No. 3 control and No. 4 independent release air hoses cannot be coupled between locomotives fitted with 26L brake equipment.

A competent employee, qualified for 26L brake operations must travel on the 'dead' locomotive for the purpose of releasing the locomotive brakes, by depressing the independent brake valve handle when the brake pipe pressure is restored upon each release of the automatic brake from the leading locomotive.

(a) Driver's brake valve cut off valves are to be in the 'out' position.

(b) Automatic brake valve handle is to be placed in the 'handle out' position and removed.

(c) At the brake pedestal being operated on the 'dead' locomotive, the independent brake valve handle is to be carried in the release position and the MU valve placed in the 'lead or dead' position.

(d) Accelerating handle in off position, reverser handle removed in isolate and regenerative handle in the 'off' position.

(e) Main reservoir and brake pipe air hoses are to be coupled between the locomotives and associated air cocks opened.

(f) Brakes are to be applied and released from the leading locomotive and their correct operation checked on the 'dead' locomotive before departure.

NOTE: When a main reservoir air supply is not available from the assisting locomotive the dead locomotive device is to be placed in the open position to charge the main reservoir on the 'dead' locomotive.

Enginemen are reminded that due to their restricted length, Nos.3 and 4 air hoses will not remain coupled between a 46 class and 85 class locomotive and failure to carry out the foregoing instructions will result in brakes failing to release on a trailing 85 class locomotive after an automatic brake application.

Hauling of Dead Locomotives from a Depot

When a locomotive is being hauled 'dead' from a depot it will be the responsibility of Depot officers making these arrangements to ensure that the 'dead' locomotive is correctly set up, the air brake equipment is properly positioned and connected for dead haulage and that the brakes apply and release satisfactorily when remotely controlled from the hauling locomotive.

It is not necessary for the Driver of the train by which the dead locomotive is hauled between depots to be qualified for it, but, if he is qualified for the type of brake equipment with which it is fitted, he will be expected to effectively deal with any brake troubles occurring enroute.

FUSES

The following fuses are provided in the high tension compartment:-

(a) A group of three 10 amp fuses which are:-
  (i) Polarity detector positive and negative fuses. These fuses protect the polarity detector circuits which ensure a slightly higher voltage is present in the traction motor armature than in the overhead before the line switches close and regenerative brake becomes effective. Should a fuse fail, regenerative brake becomes inoperative and if the regenerative handle is open, the red fault light will shine and alarm bell sound. To correct the fault, press the reset button and if this fails to have the desired effect, test and renew the 10 amp fuse.

(ii) No volt relay fuse.
This fuse protects the no volt relay circuit and in the event of it failing, overhead supply is lost and the line switches will open, causing the red fault light to shine and alarm bell to sound.
Close the accelerating or regenerative brake handles and press the fault reset button. Should this action fail to correct the defect, test and if necessary renew the 10 amp fuse.

(b) Two compressor 20 amp fuses, one for each compressor. Should either of these fuses fail, the compressor will stop and it will be necessary to test and renew the defective fuse.

(c) A group of three (3) regenerative brake fuses.
These fuses are bolted on the wall adjacent to the motor alternator (MA) set and must not be renewed by enginemen.

(d) One spare 20 amp and one spare 10 amp fuse are located in the high tension compartment.

DRIVER'S, SPARE AND EMERGENCY EQUIPMENT

The following equipment shall be carried on 85 class electric locomotives:-

Driver's Equipment

1 tail disc.
2 cases of 12 detonators. One in each cabin.
2 red flags (in flag cases). One in each cabin.

Tools

1 spanner, hose M.R. and B.P.
1 " " Bogie M.R.
1 " " " B.Cyl.
1 " " " Sand
1 pin punch
1 chisel
1 hammer

Spare and Emergency Equipment

1 screw wrench
1 brake pipe hose - 25 millimetres
1 brake pipe hose - 32 millimetres
1 rope - 1220 millimetres.
Spare fuses - Compressor 20 ampere
- no volt relay 10 ampere
1 hook stick
3 fire extinguishers.

FAULTS, FAILURES AND THEIR REMEDY

The following is a complete coverage of the defects that may manifest themselves due to the malfunction or complete breakdown of equipment and the appropriate action required of the driver.

In the event of a defect developing, before attempting to rectify the fault, ensure all circuit breakers are on and check which fault light is shining.

1. Discharged Battery

In this case the auxiliary machines cannot be started when battery voltage is less than 70 volts DC until coupled to another 85 class locomotive.

Remedy

(a) Couple another locomotive to the unit with flat batteries.

(b) Connect the jumper coupling between the units.

(c) Check that motor alternator is operating on normal locomotive.

(d) Break seals and place "Remote supply" circuit breakers (RSB) on both locomotives in "ON" position.

(e) Raise pantographs on disabled unit and start the motor alternator and compressors.

(f) Place the remote supply breakers (RSB) in the "OFF" position on both locomotives once motor alternator commences operation.

(g) Enter defect in log book.

Caution

Be sure remote supply breakers (RSB) are turned "Off" before coupling or uncoupling locomotives otherwise severe burning of the jumper pins will occur.

2. Lights will not go on when motor alternator is not running

The following items are to be checked:-

(a) Battery isolating switch is closed.

(b) All miniature circuit breakers (MCB) are "ON".

(c) Renew battery positive or negative fuses if required located in fuse box adjacent to storage batteries.

3. Pantograph will not go up

The following items are to be checked:-

(a) Reverser handle is not in "Isolate".

(b) High tension compartment door is closed and correctly locked.

(c) Pantograph control circuit breaker is "ON"

(d) Air supply isolating cocks on bulkhead in machine compartment correctly positioned.

4. Line Voltmeters do not register

The following items are to be checked:-

(a) Pantograph is up.

(b) Pantograph isolating switches in high tension compartment correctly located.

(c) If the line voltmeter is not registering a reading and power is available (indicated by motor ammeter registering a reading) the locomotive may be operated normally. A suitable entry is to be recorded in the log book.

5. Both compressors fail or will not start

The train is to be brought to a stand immediately and secured by the application of sufficient hand brakes to hold it stationary and protected in accordance with regulations.

The following items are to be checked:-

(a) Line voltmeter is registering overhead supply is available.

(b) Compressor control circuit breaker.

(c) Compressor governor synchronising circuit breaker (CMGB).

(d) Train control circuit breaker (TCB).

(e) Compressor governor isolating cock open and contact points closed.

(f) Compressor switches CMS1, CMS2 correctly positioned.

(g) Test and renew compressor fuses if required.

Note: When operating in multiple unit consists the governor synchronising circuit breaker (GSCB) should also be checked.

6. One Compressor only fails or will not start

Continue with normal operation if sufficient air pressure available and at earliest convenient opportunity:-

(a) Check compressor motor switches (CMS1, CMS2) are turned "ON" in electrical cabinet.

(b) Renew 20 ampere compressor fuse.

7. Failure of motor alternator

The following items are lost:-

(a) One source of supply for low tension circuit.

(b) Battery charging.

(c) Traction motor blowing and pressurisation of high tension compartment.

(d) Resistance fans.

(e) Regenerative brake.

(f) Air conditioning.

(g) Automatic notching and transition change.

(h) Cab heaters, hotplates, demisters.

Effect
The alarm circuit will be energised causing the blue light to shine and alarm bell to sound. The battery ammeter will also register a discharge. Should the defect be on the motor side of the alternator the red fault light (FIL) will also shine.

Remedy

Return accelerating or regenerating handle to "OFF" position. Press reset button to reset high speed breaker.

The following items are to be checked:-

(a) Line voltmeter indicates overhead supply.

(b) Press "Pan up" button to reset auxiliary relay (AR)

(c) Press reset button to reset high speed breaker (HSB)

(d) Supply indicator switch (SIS)

(e) Train control breaker (TCB)

(f) Motor alternator control breakers (MACB)

(g) Supply isolating breaker (SIB)

(h) Alternator circuit breaker (No. 2 end R wall).

If the alarm still operates, manually operate both auxiliary relay reset buttons.

When the defect cannot be rectified to silence the alarm and extinguish the blue light, turn off the supply isolate switch on the circuit breaker panel.

Under these circumstances, the motor alternator is a failure, the traction motor blowers and resistor blower fans will not operate.

Notching is only possible in positions 1 to 3 of the accelerating handle and the locomotive can only be operated up to full series.

The ammeter readings are to be controlled during notching in resistance up to a maximum of 400 amps which restricts operation to light locomotive running only.

The notching of starting resistances out of circuit must be completed within sixty (60) seconds to prevent overheating of the resistances without the blower fans.

Should this period be exceeded, then power to the traction motors is interrupted and cannot be re-applied for a period of three minutes. The amber light for failed resistor blower will shine and alarm bell will sound.

When operating under these conditions, the following ammeter readings must not be exceeded.

150 amps continuous
230 amps for twenty five (25) minutes
270 amps for fifteen (15) minutes

Regenerative brake is inoperative.

POWER FAULT INDICATOR RED LIGHT SHINES

Whenever the line switches open on fault with the accelerating or regenerative handles in the open position and the control circuit is complete, the red light will shine and alarm bell will sound.

In addition, upon the line switches opening the motor alternator (MA) set will also stop and therefore the blue light will also shine.

The energising of the alarm circuit will cause the light(s) to shine on the affected unit and the alarm bell to sound on all units due to the following:-

1. Fault in traction circuit.
   One of the following circuit breakers may be tripped.
   Train Control, control positive or pilot motor.
2. Overcurrent to traction motors (overload relays tripped 1400 amps).
3. Fault on motor alternator (stopped).
4. Overvoltage relay tripped (2050 volts) applies in either motoring or regeneration.
5. Failure in camshaft control (Pilot motor circuit breaker tripped).
6. High speed circuit breaker tripped.
7. Opening of control governor (Pneumatic control switch).
8. Loss of overhead supply (check line voltmeter. No volt relay may have operated).
9. Resistance overheat detector operated (amber light and bell functions).
10. Polarity detector 10 amp fuse blown when operating in Regenerative braking.

To assist in rectifying the defect, press the fault reset button with the accelerating or regenerative brake handle in the "off" position. Should this action fail to correct the fault, the following items of equipment are to be checked:-

(a) Train control, control positive or pilot motor circuit breakers are not tripped.

(b) Brake pipe pressure exceeds 350 kPa to close control governor (Pneumatic control switch).

(c) Resistance overheat device has not functioned which is indicated by the presence of the amber light and bell.

(d) Test and if necessary, renew any one of the three (3) ten amp fuses in the high tension compartment viz:- positive and negative polarity detector and no volt relay fuses.

When the indicator light shines when powering, return the accelerating handle to the 'off' position and press the reset button. The indication will be extinguished and bell ceases to sound after the motor alternator restarts.

Note: The reset button is not effective when the reverser handle is in 'isolate' or the train control circuit breaker (TCB) or control positive circuit breaker (CPB) is in the 'off' position.

If the alarm bell and indicator light operate again before operating the accelerating handle or regenerative handle of the master controller, this indicates a failure of the motor alternator. Isolate the motor alternator.

When a defect is not evident, check line voltmeter is registering and if so, check the ten (10) amp no volt relay fuse in the high tension compartment and renew if necessary.

If the alarm bell and the indicator light operate again when the accelerating handle is open, the unit should be isolated.

Do not reset repeatedly because it may seriously damage the electrical equipment.

When the alarm operates in regenerative braking return the regenerative handle to the 'off' position; if the alarm ceases to operate it would indicate the overvoltage relay had operated.

If the alarm operates repeatedly do not continue to use regenerative braking. Turn off regenerative brake control breaker (RCB).

In the event of the indicator light not being extinguished by returning the regenerative handle to the 'off' position press the reset button. If the alarm operates when regenerative brake is reapplied after resetting do not use regenerative braking.

FAILURE OF ALTERNATING CURRENT (AC) SUPPLY FROM THE MOTOR ALTERNATOR OR BATTERY CHARGER INOPERATIVE

The alarm circuit will be energised causing the blue light to shine and alarm bell to sound should the failure occur on the motor side of the alternator, then the red fault light will also shine with the accelerating and/or regenerative brake handle in the 'off' position.

The following items are to be checked:-

1. Line voltage is more than 1100 volts.
   Note: If the line voltage is less than 1100 volts then the no volt relay will function.

2. Accelerating and regenerative brake handles are in the 'off' position.

3. Press the fault reset button if the red indicator light is shining.

4. Motor alternator (AC) supply circuit breaker is not tripped.

5. Battery charger circuit breaker is not tripped.

6. Supply indicator circuit breaker is not tripped.

When the defect cannot be rectified to silence the alarm and extinguish the blue light, isolate the motor alternator by turning off the supply isolate switch.

Under these conditions, the motor alternator is a failure, the traction motor blowers and starting resistor blower fans will not operate. Notching is only possible in positions 1 to 3 of the accelerating handle and the locomotive can only be operated up to full series.

The ammeter readings should be controlled during notching in resistance to a maximum of 400 amps which will restrict operation to light locomotive running only.

The notching of starting resistances out of circuit must be completed within sixty (60) seconds to prevent overheating of the resistances without the blower fans.

Should this period be exceeded, then power to the traction motors is interrupted and cannot be re-applied for a period of three (3) minutes.

In addition, the failed resistor blower fan amber light will shine and alarm bell will sound. When operating under these conditions, the following ammeter readings must not be exceeded.

150 amps continuous
230 amps for twenty five (25) minutes
270 amps for fifteen (15) minutes

Regenerative brake is not available.

FAILED RESISTANCE FAN, TRACTION MOTOR BLOWERS OR RESISTANCE THERMAL DETECTOR OPERATION

The alarm circuit will be energised causing the amber light to shine and alarm bell to sound.

The following items of equipment are to be checked:-

Ascertain whether traction motor blower or resistance blower fan is defective.

(a) Check blower control switch on driver's control stand is "ON".

(b) If thermal overheat detector operates. The red light will shine and it will be necessary to press the fault reset button.

(c) Check blower motor control circuit breaker (BMCB) is "ON"

(d) Check traction motor blower circuit breakers are "ON".

(e) Check resistance blower circuit breaker (RBB) are "ON".

NOTE: There is a time delay in blower fans starting up when accelerating handle is opened as previously described.

When the defect cannot be rectified, the locomotive is only to be operated light in accordance with the following:-

If the resistance fans or traction motor blowers fail for any reason or if the thermal overheat device in the main resistance boxes operate this alarm will be energised.

A check should be made of the circuit breakers and switches.

It will be necessary to wait fifteen (15) minutes for the resistances to cool and for the alarm to be de-energised should the alarm operate more than twice in quick succession

and train working conditions are not such as to permit a cooling down of resistances the unit should be considered a failure and isolated. If train working conditions would permit a cooling down of resistances e.g. reaching the top of a grade with a downhill or lighter grade continue with operation.

Failure of resistance cooling and/or traction motor blowers the following amperages must not be exceeded.

270 amps - 15 minutes
230 amps - 25 minutes
150 amps - continuous.

WHEEL SLIP/SLIDE LIGHT AND BUZZER FAIL TO OPERATE

Remedy

(a) Check wheel slip circuit breaker on circuit breaker panel is not tripped.

Sanders will not operate

Remedy

(a) Reverser handle correctly positioned for direction.

(b) Control positive (CPB) circuit breaker is not tripped.

(c) Check sander magnet valve isolating cocks on right wall in machine compartment.

Horns will not operate

If main reservoir pressure is available check isolating cocks for respective cab control.

No. 1 end cab

(a) Isolating cock on bulkhead in machine compartment.

(b) Isolating cock in small compartment adjacent to hotplate.

NOTE: Isolating cock on bulkhead isolates air supply for high tension door interlock, sands No. 1 end, windscreen washer, wipers, refrigerator.

No. 2 end cab

(a) In small compartment adjacent to hotplate check lower

(b) and horn isolating cocks in open position,

NOTE: Lower isolating cock isolates air supply to horns, windscreen washers, windscreen wipers, refrigerator on No. 2 end.

Cab Amenities

Respective circuit breaker turned "ON" on circuit B panel.

PROCEDURE WHEN LOCOMOTIVE WILL NOT MOVE OR LOSES POWER WHEN MOTORING OR REGENERATING

If on a steep falling grade bring the train to a stand applying the automatic brakes.

Return the accelerating handle or regenerating handle to the "OFF" position.

Check - Overhead current available.

(a) Train control circuit breaker is not tripped.

(b) Main control circuit breaker is not tripped.

(c) Control circuit breaker is not tripped.

(d) Pilot motor (CB) is not tripped.

(e) Control positive circuit breaker is not tripped.

(f) Regenerative control breaker is not tripped.

(g) Low control air pressure.

(h) Low brake pipe air (control governor (CG)) will open and this in turn will trip the high speed circuit breaker and open the line switches.

If the motor ammeter does not read:-

Check	Supply is proved if:-	Action if no supply
1. Overhead supply	Line voltmeter reads or motor alternator operates or compressors operate	Ensure pantograph in contact with wire and pantograph isolating switches closed. High tension door interlock is properly locked.
2. Battery supply	Motor alternator operates or compressors operate or any loco lights operate	Check battery isolating switch is closed and battery fuses are not defective.
3. Control circuit supply	Motor alternator operates or line switches close or indicator lamps light	Check Pilot motor control (PMB) Control circuit (CCB) Control Positive (CPB) Regenerative brake control RCB1, RCB2.

Amber Resistance Notch Indicating Light

This light is illuminated when any of the locomotives in multiple are operating with resistances in circuit during acceleration.

BRAKE CYLINDER PRESSURE BLUE LIGHT

The brake cylinder pressure blue light is provided to warn the Driver should the brakes inadvertently apply on the locomotive or on any trailing locomotive fitted with this switch in a multiple unit consist. The light is normally extinguished while ever the brakes are released.

When pressure in the brake cylinder rises to 30 kPa, the switch closes and the blue light shines. Upon the pressure falling to 10 kPa, the switch opens, the blue light is extinguished.

The brake cylinder pressure blue light is train lined through the jumper coupling and will shine on all locomotives, when the brakes are applied on one or more of the locomotives in a multiple unit consist.

Should it be necessary to isolate the air brake on the No.1 bogie for any reason, the brake cylinder pressure warning light becomes inoperative.

Brake Cylinder Pressure Blue Light Shines

The blue warning light will shine whenever the brakes are applied and pressure in the brake cylinders exceeds 30 kPa.

Should the blue warning light shine when the locomotive(s) are being operated with the brakes released, immediate action is to be taken to release the brakes in accordance with current instructions.

NOTE: This particularly applies in a multiple unit consist as severe damage can be caused to a trailing locomotive due to the brakes failing to release from a slight overcharge of the brake pipe.

The opening of the following miniature circuit breakers may cause operating difficulties with no alarms:-

1. Train control circuit breaker (TCB)
2. Control circuit breaker (CCB)
3. Control positive circuit breaker (CPB)

4. Fault circuit breaker (FB)
5. Pilot motor circuit breaker (PMB)
6. Regenerative brake circuit control (RCB)
7. Wheel slip/slide circuit breaker (WSB)

Control Governor (CG) (Pneumatic Control Switch)

The pneumatic control switch is operated by brake pipe pressure opening if brake pipe pressure falls below 250 kPa and closing when pressure is restored to not less than 350 kPa.

When brake pipe pressure falls and the pneumatic control switch opens, it in turn trips the high speed circuit breaker and opens the line switches, causing the red fault light to shine and alarm bell to sound.

This condition will continue until the brake pipe pressure is restored and control governor closes, with the accelerating or regenerative handle in the "off" position and the fault reset button pressed.

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