



AUSTRALIAN RAIL TRACK CORPORATION LTD

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Discipline

Engineering Standard - NSW

Category

Electrical

Title

Electric Power System - Safety Aspects

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The technical content of this document has been approved by the relevant ARTC engineering authority and has also been endorsed by the ARTC Safety Committee.

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About This Standard

This publication provides general information for any person who is required to carry out work on or near any part of the Australian Rail Track Corporation Electricity Distribution System, and for any person who is required to have knowledge of the ARTC Electricity Distribution System.

In particular, it specifies various safety issues, some of which are peculiar to the electric traction railway environment, which a Contractor's Electrical Safety System should consider and address as necessary.

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1 Description of the Electrical System

1.1 High Voltage System

1.1.1 General

The Australian Rail Track Corporation high voltage system is supplied from the National Grid at a number of supply points at voltages of 11kV to 132kV.

Power is transmitted via high voltage ac transmission lines and underground cables to a number of substations. The substations contain equipment for voltage transformation, switching, overload and fault protection, voltage regulation and rectification for supply to the dc traction system.

In addition to power for electric traction, power is supplied for signalling, and also for other non-ARTC loads, such as railway stations, offices, workshops and depots.

1.1.2 High Voltage Feeder Labelling

The high voltage feeder labelling convention is described as follows:

High voltage overhead line and cable feeders are numbered in accordance with the voltage of the feeder. Numbers used are:

2kV Feeders	400 to 499
11kV Feeders	500 to 699
33kV Feeders	700 to 799
66kV Feeders	800 to 899

A small number of exceptions to the conventional numbering system exist and personnel concerned should be aware of the particular feeder numbers used.

Where a high voltage feeder is sectioned by switches, the sections are identified by adding a stroke and a number to the feeder number, for example, 66kV Feeder 829/1, 829/2, etc.

Where high voltage cable feeders comprise two cables in parallel, the cables are identified by adding a letter to the feeder number, ie the cables of 11kV Feeder 533 are 533A and 533B.

An exception to the above numbering system is the convention used for the two phase 2kV signalling and lighting feeders where letters only or letters and numbers are used. The letters are used to designate the railway line where the feeder is installed and also whether it is a signalling or lighting feeder and the numbers are used to designate the section of the feeder. For example, the 2kV signalling feeder between Sefton Junction and Chullora Junction is labelled SCJS - Sefton Chullora Junction Signalling, and the 2kV lighting feeder for the Main North line is labelled NL10 - Strathfield to Rhodes, NL14 - Rhodes to Epping, NL16 - Epping to Beecroft, and NL21 - Beecroft to Hornsby, with the NL designating North Lighting. The number indicates the approximate mileage of the far end of the feeder, eg NL14 ends 14 miles from Sydney.

1.2 1500 Volt Overhead Wiring System

1.2.1 General

Power for electric traction is supplied from substations to the trains by means of the overhead wiring system. The train pantograph sliding under the contact wire, collects current to operate the motors, the current returning to the substations through the traction rails.

Three basic types of overhead wiring are in use:

- (a) A simple catenary, where the contact wire is supported from either single or twin catenary wire by droppers spaced along the catenary. Both single and twin contact wire arrangements are used.
- (b) A compound catenary, where a main catenary supports an auxiliary catenary which in turn supports the contact wire by means of droppers, and
- (c) Contact only which has no catenary or droppers.

The majority of overhead wiring is the simple catenary type, the compound catenary is used west of Penrith and contact only is used in yards for slow running. Types (a) and (c) can be either fixed anchored, where the tensions in the wires vary with temperature, or regulated tension, where the wire tensions are held approximately constant by means of weight or gas tensioning devices. Type (b) system is fixed anchored.

In all three types the supports for the overhead wires can take the form of wire polygons (suspended between wood poles or steel masts), cantilever arrangements (erected on wood poles or steel masts), or portal structures.

The contact wire is steadied against wind and directed around curves by pull-off arms. In span wire construction the pull off arms are held by span wires stretched across the tracks between masts. In independent registration arrangements the pull off arms are attached to the structure or cantilever so that the wiring for each track is independent of adjacent tracks.

Insulators are used to separate the live 1500 volt overhead wires and equipment from the support structures and to provide electrical separation between the wiring for each track.

Figure 2.1 shows simple catenary, fixed anchored, span wire construction on portal structures.

Figure 2.2 shows simple catenary, regulated tension, cantilever construction on masts.

Weight tensioning is shown on one track and gas tensioning devices on the other track.

The substations, which feed the overhead wiring, are supplied from the high voltage system and contain transformers and rectifiers to convert the high voltage alternating current to 1500 volts direct current for the trains.

The power is fed to the overhead wiring via dc circuit breakers which provide protection in the event of faults.

Sectioning huts, containing dc circuit breakers, are provided between substations to improve voltage regulation and for protection and sectioning of the overhead wiring system.

Figure 2.3 shows a sectioning diagram for a two track arrangement between a substation and a sectioning hut.

1.2.2 1500 Volt Overhead Wiring Identification

(a) Section/Subsection

The 1500V overhead wiring section/subsection labelling convention is described as follows:

The 1500 volt system is divided into numbered electrical sections. The overhead wiring over each track between Substations constitutes a section which is odd numbered for Up tracks and even numbered for Down tracks.

The section numbers may be prefaced by one or two letters which identify the line, eg

W - Western Line
SN - Sydney to Newcastle Line

Sections are divided into subsections at Sectioning Huts and sectioning switches.

To designate a subsection a stroke and a number or a stroke and a number plus a letter are added to the section number.

At Sectioning Huts, the subsection numbers are changed.

At sectioning switches two methods are used to designate the subsections. The early method changed the subsection number at the switch. The current method retains the subsection number and letters are added to designate subsections.

Figure 2.1 shows a typical sectioning arrangement between two Substations.

The overhead wiring section between the Substations is designated PS11 (PS eleven) section for the Up track and PS12 (PS twelve) section for the Down track.

These sections are divided into subsections at the Sectioning Hut and sectioning switches.

The early method is shown on the Up track. For example, at the switch at location LT 54 + 321, Up track subsection PS11/1 (PS eleven stroke one) changes to subsection PS11/2 (PS eleven stroke two), the switch being designated PS11/1&2 (PS eleven stroke one and two).

The current method is shown on the Down track. For example, at the switch at location LT 54 + 123, Down track subsection PS12/1 (PS twelve stroke one) is divided into PS12/1A (PS twelve stroke one A) and PS12/1B (PS twelve stroke one B), the switch being designated PS12/1A&1B (PS twelve stroke one A and one B).

Where the overhead wiring for a track is fed via a switch from another track, additional numbers are added to the feeding track subsection number to designate the new subsection. For example, the down siding at Salmon Creek is fed from PS

12/2B subsection and is designated subsection PS12/21 (PS twelve stroke two one).

This labelling convention is used to describe the overhead wiring system from the electrical point of view. It is essential that correct section/subsection designations be used when describing the 1500 volt system.

(b) Structure Numbers

Overhead wiring structures are identified by a combination of letters and numbers. The letters are used to identify the track area, eg

B - is the prefix for the Bankstown Line,
BL - Belmore to Lidcombe, M
S - Main Suburban Line.

The numbers are used to identify the location of the structure along the route of the track as a distance from the datum point at Central.

The old method (imperial measurement) used foot increments eg BL 417 + 20. The numbers in front of the + sign represent “hundreds” of feet and the numbers after the + are feet up to 99 feet.

The new method (metric measurement) uses metre increments eg B 15 + 091. The number in front of the + sign represents kilometres and the numbers after the + are metres up to 999 metres.

This identification is also used to locate overbridges, substations, sectioning huts and other features which are referenced to an overhead wiring location.

The overhead wiring structure number is not to be confused with the track kilometrage eg 15.345km may not be the same as 15 + 345 due to the different measuring methods of the Civil and Electrical disciplines.

1.3 Low Voltage Distribution System

The low voltage distribution system which is supplied from numerous substations in the high voltage system, distributes via cables and aerial conductors, energy for signalling, and also for supply to non-ARTC installations such as railway stations, offices, workshops and depots.

Low voltage supply is also taken from the local Electricity Distributor where required. In many locations automatic or manual changeover equipment is provided to permit low voltage supply to be sourced from either the local Electricity Distributor or the ARTC high voltage system.

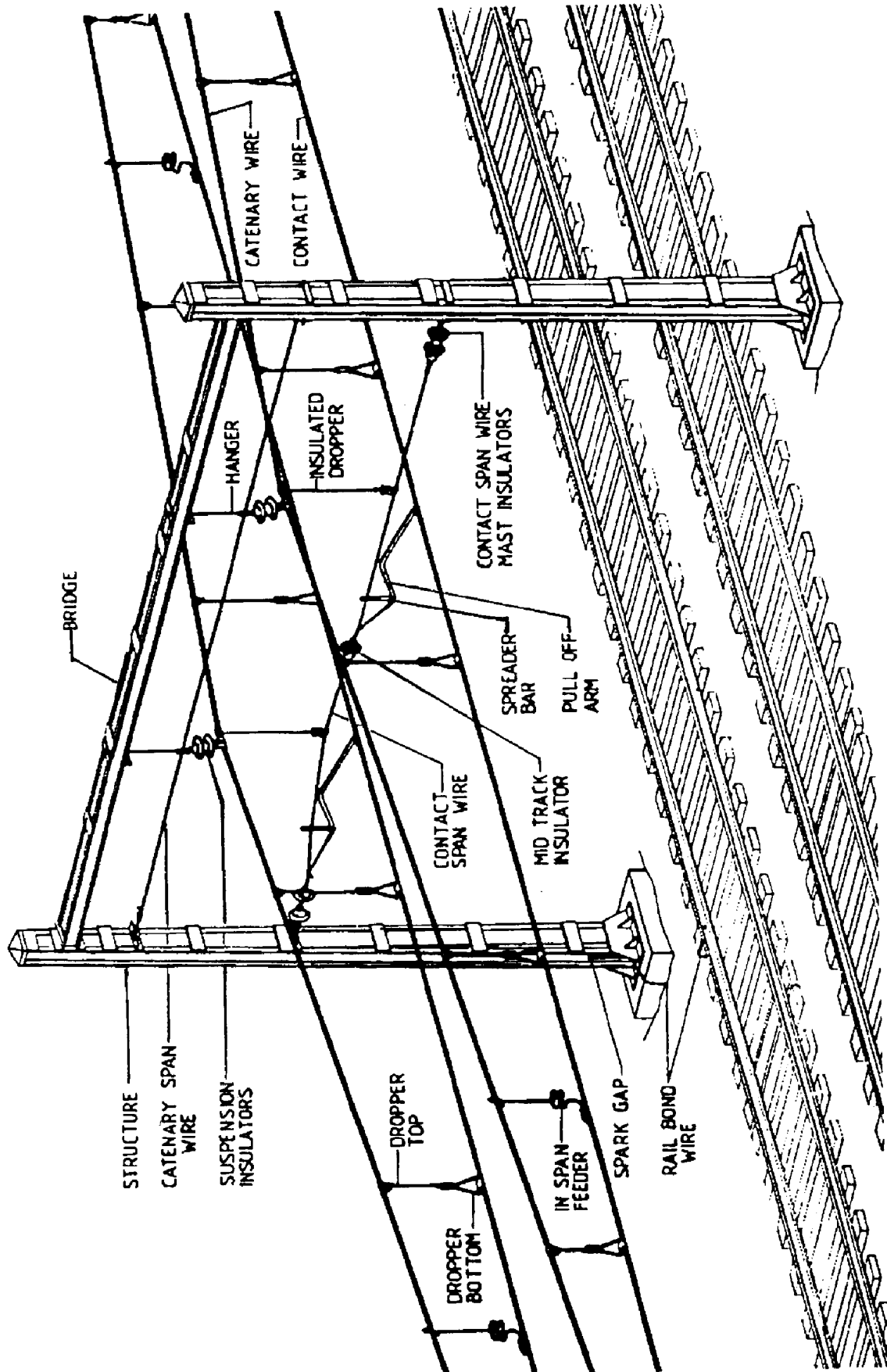


Figure 2.1

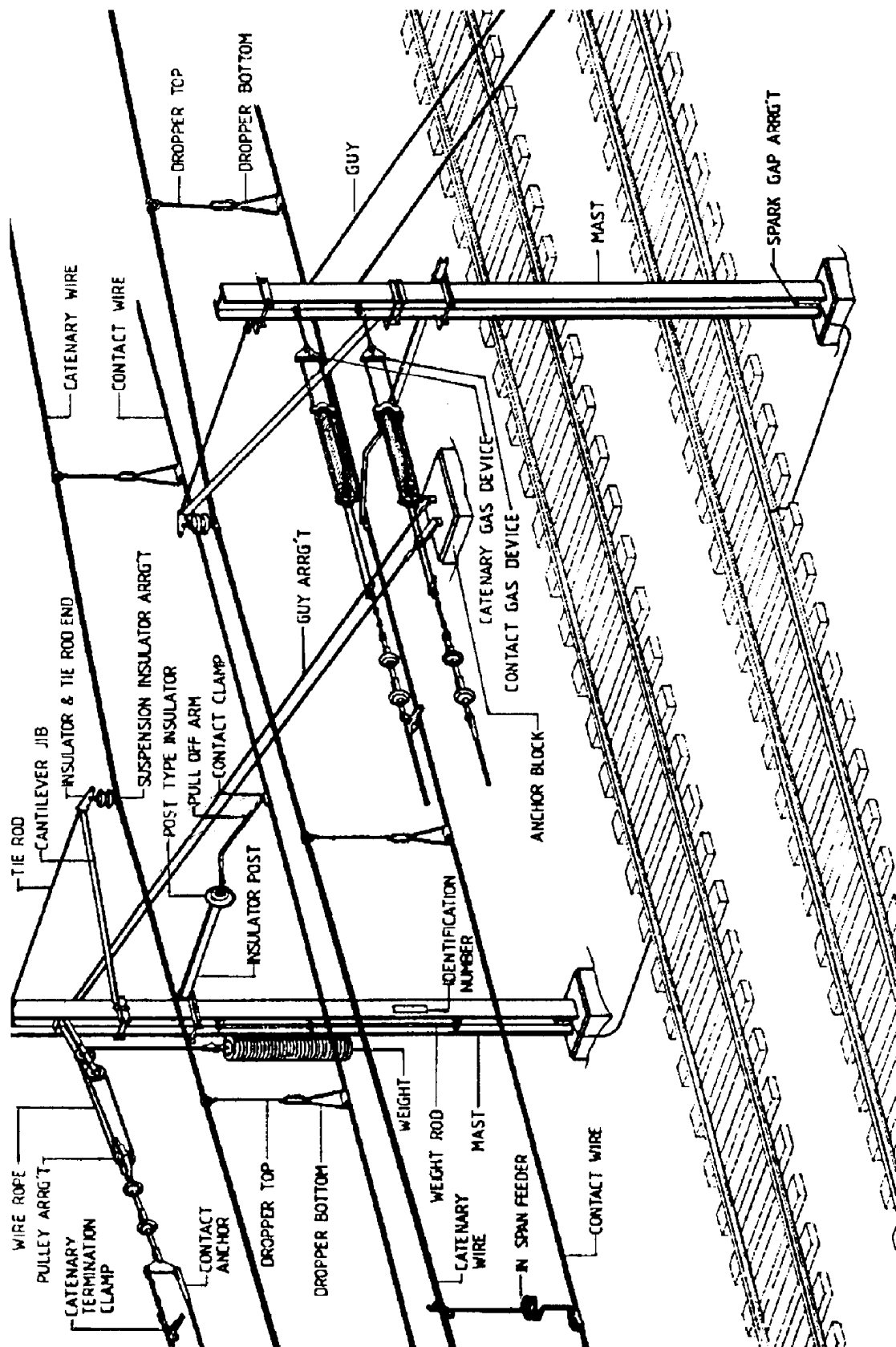


Figure 2.2

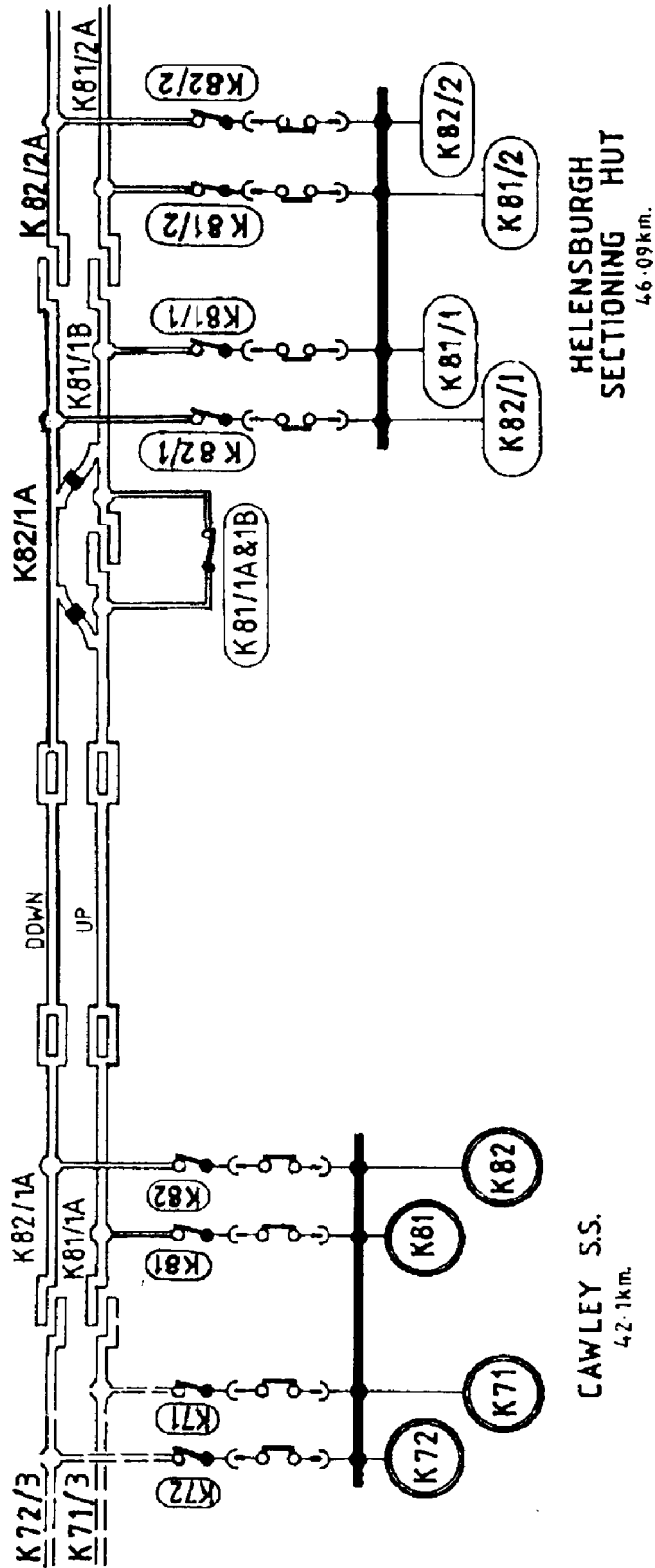


Figure 2.3

2 General Warnings and Directions

2.1 Safety-First

At all times and in all places, persons have a duty to take care.

Most accidents result from lack of care by the person injured or by some other person. Persons are cautioned not to allow familiarity with the work to give rise to carelessness.

Persons must keep their mind on the work, particularly when operating, working near live equipment or when working aloft.

2.2 Rescue

In the event of danger to human life a person may take any such action as may be necessary and appropriate. The rescuer must be particularly careful not to also become a casualty; a dead or injured rescuer can not rescue anyone!

2.3 General Requirements for Carrying Out Work

A person who works on electrical equipment must be trained for the type of work and be physically fit to safely perform it.

2.4 Reporting of Dangerous Conditions and Practices

When a person working on electrical equipment finds an unsafe condition, that condition must be guarded until made safe.

When a person observes a dangerous condition or practice in connection with the work, the details must be immediately reported to the supervisor who must record the details and take appropriate remedial action.

2.5 Determination of Safe Conditions

If for any reason any person considers that, with the arrangements that have been made, the work cannot be done or cannot be completed in a safe manner, then the work must not be commenced or the work must stop as the case may be. Revised arrangements must be made for the work to be carried out in a safe manner.

2.6 Pre-Start Safety Briefing

Before work commences, the person in charge of the work must ensure that all persons:

- understand what work is to be carried out,
- understand which part of the work requires a Permit,
- are aware of hazards, and
- are aware of the location of first aid equipment.

2.7 Hazard Assessment

In accordance with a Department of Energy directive, a written hazard assessment must be completed when working on poles or structures supporting live exposed electrical equipment, and the work requires a person to ascend the pole or structure by more than 1.0m (refer document PGP 02 - "Hazard Assessment and Work Process Controls").

2.8 Obstructing Entrances and Exits

Except for brief periods of inspection, the entry and exit to a substation, cable chamber, cable tunnel or confined space must not be obstructed.

2.9 Work Near Electrical Equipment

Persons must treat all electrical equipment as live unless they are signed onto a Permit for that equipment or another provision of the Electric Power System Safe Operation Manual applies.

Requirements for work near electrical equipment are outlined in documents PMP 09 "Work Near High Voltage Equipment – Permit Requirements and Safe Working Distances", PMP 13 "Work Near 1500 Volt Equipment – Permit Requirements and Safe Working Distances", and PMP 14 "Work on or Near Low Voltage Distribution Equipment – Permit Requirements and Safe Working Distances".

For the purpose of the Electric Power System Safe Operation Manual, the following activities are **not** considered to be work near electrical equipment provided they do not bring the operator within the relevant electrical safe working distances:

- the operation of switches and link switches,
- the use of specially insulated apparatus,
- the application of earths,
- the application of rail connections, and
- work on disconnected equipment.

The replacement of globes and tubes for general service lighting is not considered to be work near low voltage electrical equipment.

2.10 Working Alone Near Electrical Equipment

Persons working near exposed high voltage equipment, 1500 volt equipment, live low voltage equipment in substations, or live low voltage overhead lines must be accompanied except where there is immediate risk to human life or property.

The accompanying person must be:

- accredited in resuscitation and releasing a person from live electrical apparatus, and
- able to use communication equipment in case of an emergency.

2.11 Work Aloft

Only a person who has received appropriate and documented training for the work and who is currently authorised to do so is permitted to work aloft supported on a pole or structure.

A person must not ascend a pole or a structure which is condemned or is found to have suffered deterioration or damage to an extent which may cause it to collapse, unless it is effectively secured.

A pole safety belt must be worn and the strap must be secured except while actually climbing or changing position.

If an accompanying person is required by **2.10**, the accompanying person must be accredited in rescuing a person from a pole or structure and a rescue kit must be available.

2.12 Work from Hinged or Telescopic Boom Elevating Work Platforms

Whenever the platform is elevated, persons in work platforms elevated by means of a hinged and/or telescopic boom must wear:

- a general purpose safety belt fitted with shoulder straps, or
- a pole safety belt fitted with shoulder straps, or
- a general purpose safety harness.

The safety line attached to the belt or harness must be attached to the appropriate anchorage point. The length of the safety line must not be longer than is necessary to permit the wearer of the belt or harness to move freely while standing on the floor of the elevating work platform.

A separate emergency escape controlled descent device must be available for each person in the elevating work platform.

All persons who are to work in such elevating work platforms must be instructed in the safe use of the belts or harnesses and the emergency escape controlled descent devices prior to work commencing.

If an accompanying person is required by **2.10**, the accompanying person must be accredited in rescuing a person from an elevating work platform.

2.13 Work On or Near Cables

2.13.1 Approach to High Voltage or 1500V Cables

For the purpose of approach by persons, tools, materials, plant etc., to cables that do not have an earthed metallic sheath or screen, the cable must be treated as exposed equipment. Where an earthed metallic sheath or screen exists but its condition is doubtful or suspect the cable must be treated as exposed equipment.

NOTE: A reduced safe working distance applies for 1500 volt cables in this situation (refer to publication PMP 13 "Work Near 1500 Volt Equipment – Permit Requirements and Safe Working Distances").

When an earthed metallic sheath or screen exists and is exposed, precautions must be taken where necessary to avoid danger from induced voltage and transferred earth potential prior to the cable being approached.

2.13.2 Handling of High Voltage or 1500V Cables

When it is necessary to move or bend a high voltage or 1500V cable the persons handling the cable must be signed onto an appropriate Permit whilst the cable is handled.

NOTE: If the cable is to be flexed significantly an insulation resistance test must be carried out prior to the cable being moved and again prior to returning the cable to service to ensure the continued integrity of the cable.

2.13.3 Work on Cables

Persons must not commence work on any cable until:

- the cable has been positively identified at the worksite, and
- the person has signed onto the appropriate Permit.

A Permit may not be required for work on low voltage cables when the work is being carried out by a suitably qualified or authorised person (refer to publication PMP 14 "Work on or Near Low Voltage Distribution Equipment – Permit Requirements and Safe Working Distances ").

Cable jointing work on high voltage or 1500 Volt cables must only be carried out by authorised cable jointers.

At cable work sites, there is a danger of induced voltages and transferred earth potentials from adjacent cable or substation faults. Persons should work on one conductor or sheath at a time and should not bridge themselves between conductors or sheath and earth.

2.13.4 Excavation in the Vicinity of Cables

For the purpose of this clause, excavation includes excavation, boring, grading or post driving.

Excavation works must not be commenced unless underground services search information has been obtained, in writing, and the position of any service expected

to be in the vicinity has been marked out in the field. All instructions specified by the underground service owner on the services search form(s) must be complied with.

Generally, excavation by machine must not be carried out within the following distances of the expected position of buried ARTC cables without first exposing all the buried cables by hand excavation.

- low voltage cables - **1.0m** measured horizontally.
- high voltage cables - **2.0m** measured horizontally.

In cases where ground conditions make hand excavation impractical, a mechanical excavation method may be used subject to the approval of the Electrical Engineer.

Excavation within the above distances must be carried out by persons signed onto an appropriate Permit unless:-

- a safe work procedure to prevent damage to the cable, approved by the Electrical Engineer is used, and
- all persons carrying out the excavation are instructed in this procedure, and
- the person carrying out the excavation is continuously and closely supervised by another person who has been instructed in the procedure.

Prior to backfilling the excavation, any cables exposed must be inspected by the Electrical Engineer's nominated representative. All protective slabs, marker tapes, etc., must be restored.

Cables in ground line troughing (GLT) or in pegline (e.g. elevated steel troughing) need not be isolated for excavation in the vicinity unless there is a risk of the cables being damaged.

2.14 Operation of High Voltage and 1500 Volt Equipment

Only Authorised Persons are permitted to operate high voltage and 1500 volt equipment. The Authorised Person must ensure that approval is obtained from the Electrical System Operator prior to carrying out any such operation except when a life threatening situation exists.

Special instructions apply for 1500 volt switch operations at Electric Vehicle Maintenance Centres and at specified locations.

Electrical equipment must be operated in accordance with the requirements of publications POP 05 "Operating Work – High Voltage System", RailCorp publication EP 95 20 00 05 SI "Operating Work – 1500 Volt System", and POP 06 "Operating Work – Low Voltage Distribution System".

2.15 Completion of Electrical Safety Forms

When completing Permits and other electrical safety forms the following requirements must be complied with:

- All entries, other than signatures, must be printed. Care must be taken to make the writing clear and legible.
- All entries must be completed firmly using a ballpoint pen.
- Where a signature is required, the person must sign in their normal signature.
- All times must be shown using the 24 hour clock system.
- All deletions must be made by neatly crossing out the words to be deleted in a manner that, as far as possible, does not totally obscure them. The deletion must be initialled and dated by the person making it.

2.16 Radio and Telephone Communications for Switching Operations

When staff converse with the Electrical System Operator the following communications procedures must apply:

- the person's name, position and present location must first be given to the Electrical System Operator, and
- all instructions must be repeated back to the sender for confirmation, including all switch numbers, section/subsection number, etc. Instructions must not be carried out unless the sender has confirmed that the instruction has been received correctly.

Persons responsible for using communications equipment must regularly test the equipment to establish that it is functioning correctly and ensure that the equipment is taken to the worksite, is switched on and is ready for use.

2.17 Interfering with Danger Tags

Danger Tags are placed for the safety of persons.

Danger Tags must not be interfered with or removed without the proper authority.

2.18 Interfering with Portable Rail-Connecting Equipment

Persons must ensure that the connection to rail of portable rail-connecting equipment is not damaged or disconnected. If accidental damage or disconnection occurs, electrical personnel are to be advised immediately.

If it is necessary for a portable connection to be relocated for work to proceed, arrangements must be made with electrical personnel.

The connection to rail of portable rail-connecting equipment must not be interfered with or removed without the proper authority.

2.19 Entry to Substations

Persons must not enter a substation unless they are authorised to do so or are accompanied by an Authorised Person who will be responsible for their safety. The Authorised Person must not admit more unauthorised persons than can be adequately supervised having due regard to the persons being admitted and the hazards present.

Minor work, not involving high voltage or 1500 volt equipment may be carried out by unauthorised persons under the continuous and close supervision of an Authorised Person. If continuous and close supervision cannot be provided an appropriate Permit must be issued for the work.

2.20 Warning Signs, Etc

Appropriate warning signs, barriers, guards, plates, warning lights, etc, must be used as required where hazards exist to employees or the public.

2.21 Fire Fighting in the Vicinity of Electrical Equipment

Electrical testing has confirmed that fires associated with live 1500 volt electrical equipment can be safely extinguished using hand-held extinguishers and fire hoses when the conditions outlined below are complied with:

- Fire extinguishers marked "suitable for use on electrical fires" may be used to extinguish a fire associated with live 1500 volt equipment. The extinguisher's nozzle must not be used any closer than **1.5m** to the live 1500 volt equipment.
- Fire hoses may be used to extinguish a fire associated with live 1500 volt equipment. The nozzle or branch of the hose must not be used any closer than **3m** to the live 1500 volt equipment,
- Fresh water must be used for fire fighting. If brackish or salt water only is available, the electrical supply must first be removed if the fire involves live 1500 volt equipment.

If a major fire occurs in a vehicle in an electrified area, arrangements are to be made with the Electrical System Operator to remove supply from the 1500 volt overhead wiring so that, if the fire damages the overhead wiring, fallen live wires will not create additional hazards.

In case of fire in the vicinity of 1500 volt equipment along the railway lines, care must be taken to prevent any person from coming into contact with the 1500 volt equipment. Persons must be made aware that, in addition to direct contact, there is a risk of contact through falling material, water, or other conducting materials (see also section 4.5 Hazardous Conducting Objects and Materials).

WARNING

Fires in electrical substations, sectioning huts, transformer rooms, cable tunnels, pole tops, signalling locations and other places containing high voltage equipment must not, under any circumstances, be attacked by staff who are not familiar with the hazards involved. Fires of this nature must be immediately reported to the Electrical System Operator. The Electrical System Operator must call the relevant Fire Brigade.

3 Tools and Safety Equipment

3.1 Personnel Responsibilities

Any person working on or near electrical equipment must:

- use appropriate tools and safety equipment,
- ensure the tools and safety equipment are in good condition and in working order before use,
- use the tools and safety equipment in the proper manner, and
- arrange for the replacement of defective tools and safety equipment.

Defective safety equipment must not be used if the defect renders the equipment dangerous.

3.2 Tools & Safety Equipment

Appropriate tools and equipment, insulated for the voltage concerned, must be used for work on or adjacent to live exposed electrical equipment.

The tools and equipment must be inspected and/or tested before each use, and periodically tested in accordance with industry and manufacturer's standards.

Tools and safety equipment which may be required for work on the ARTC Electricity Distribution System includes, but is not limited to:

- Insulated tools and equipment for work on or adjacent to live exposed electrical equipment;
- Rescue equipment, for the rescue of persons from aloft, from live electrical switchboards and from confined spaces;
- Safety helmets;
- Safety belts and harnesses;
- Protective clothing and footwear.

4 Electrical Hazards

4.1 General

- Electrical accidents can result in:
- Persons receiving an electric shock (cardiac arrest),
- Persons receiving burns from electric current conducted through the body,
- Persons receiving radiation burns,
- Persons being burnt by hot gas,
- Persons being burnt by molten metal,
- Persons suffering flash injury to the eyes,
- Explosion,
- Fire,
- Inhalation of smoke and fumes.

In each case the result may be fatal, either directly or due to a subsequent fall.

Persons must treat every situation as potentially dangerous and only proceed when it is known that it is safe to do so and that the required safety procedures have been followed.

4.2 Electric Shock

WARNING

Contact with live exposed electrical equipment may cause death or severe injury.

Attention is drawn to the following points:

Materials such as flesh, metal, tree branches, clothing, wet ropes, flames, etc, are all capable of conducting current.

The human body is a conductor and severe injury or death will result if a conducting path is formed allowing current to pass through the body.

A conducting path may be formed by:

- touching the exposed electrical equipment with any portion of the body, or
- bringing any portion of the body so close to the exposed electrical equipment that an arc occurs between the equipment and the body, or
- bringing close or touching the exposed electrical equipment with tools or materials which are in contact with, or close to the body.

All tools and material must be regarded as conducting unless there is definite knowledge that the item concerned is suitable (and approved if appropriate) for use at the voltage concerned.

A danger of electric shock exists wherever a person could make contact between:

- live conductors, or
- a live conductor and earth, or
- overhead wiring and rail, or
- different overhead wiring sections, or
- overhead wiring and earth, or
- different earthing systems, or
- broken earthing or traction return conductors.

4.3 Electric Arcs

Serious injury can result from burns caused by electric arcs. Arcs can be caused by attempting to apply an earth or rail connection to live equipment, or by opening isolating switches carrying current. Electric arcs may be the source of an explosion which will scatter molten material, radiate intense light and heat, and emit dangerous quantities of hot gas. Serious burns and eye injuries may result.

4.4 Explosion

The electrical energy available through a fault on an electrical power system, particularly an underground cable system, can be substantial.

The destructive potential of the resulting rapidly expanding hot gas, and the other solid material which it may propel, should not be underestimated.

Under fault conditions extreme electro-magnetic forces can also have unexpected and destructive consequences.

4.5 Hazardous Conducting Objects and Materials

4.5.1 Materials that Conduct Electricity

All materials including liquids and gases must be regarded as conducting materials unless there is definite knowledge to the contrary.

4.5.2 Metallic Tapes

Steel tapes, metal reinforced linen tapes and long steel rules can be very dangerous and must not be used:

- when taking measurements near live exposed electrical equipment, or
- when there is any likelihood that the metal tape etc may bridge between metal objects which may be at different potentials, for example:
- between rail and overhead wiring structures; and
- between structures and fencing or metallic troughing.

Non-conducting tapes and sticks which have been electrically tested, approved and branded may be used.

4.5.3 Cranes, Vehicles and Plant

When cranes, vehicles or plant fitted with elevating units or tipping trays and items such as extendable lighting masts, etc, are being used in the vicinity of electrical equipment, dangers may arise owing to the possibility of error of judgement and also the possibility of sudden unexpected movements in unstable positions. Refer to publication PMP 04 - "Requirements for Work Using Cranes and Plant".

4.5.4 Flames in the Vicinity of Electrical Equipment

Flames and associated hot gases are good conductors and care must be exercised when using flame-producing items near electrical equipment. Blow lamps and welding and cutting torches can, under certain circumstances, throw a long stream of flame. Flames in the vicinity of live exposed equipment can cause an arc to form along the path of the flame if a tongue of flame or vapour makes contact with the exposed equipment.

4.5.5 Other Hazardous Articles

Long metal objects such as:

- ladders,
- long tools,
- scaffolding,
- lengths of metallic pipe, conduit, etc.,
- portable radio telephone units with telescopic aerials,
- guttering, metal roof or wall sheeting, and
- wire,

as well as long non-metallic articles including rope, tree branches and other similar long articles can be a hazard if not handled with care to keep them away from electrical equipment. Care must be taken to ensure that these types of items are not placed or used in positions where they are likely to fall, come in contact with, or be blown across live equipment.

4.6 Fallen Wires

All persons must protect themselves and others from the danger of making contact with or approaching fallen aerial conductors or objects that are in contact with the fallen conductors.

All such wires and objects must be treated as live and this precaution must not be relaxed until the required Permit has been issued.

All persons working in the 1500 volt electrified area must understand that, although a contact or catenary wire may have fallen to the rails and caused a short circuit, it does not mean that the 1500 volt supply has been isolated and made safe. On the contrary, the Electrical System Operator would continue to switch supply onto the overhead wiring at intervals. When the Electrical System Operator is informed of fallen overhead wiring, supply will be removed from the damaged and adjacent sections to reduce the electrical danger at the site. The area will not be safe until the required Permit has been issued.

Following a derailment or collision, care must be taken when approaching vehicles that may be in contact with overhead wiring, as separation of the vehicle from the rails could cause the vehicle to be live at 1500 volts.

4.7 Concealed Cables

4.7.1 Cables Concealed in Buildings and Structures

The presence of cables concealed within buildings and structures must be considered before any work such as cutting or drilling is commenced.

Where it is not possible to positively determine that there are no cables in the way before work commences, the person in charge of the work must seek advice from the Electrical Engineer who may require specific procedures to be followed. Work must not commence until the situation has been investigated and advice has been received.

4.7.2 Buried Cables and Underground Services

The presence of underground cables and other buried services must be considered before any work involving digging, excavating, boring, piling, installing fence posts, or driving electrodes etc, is commenced in any area.

The person in charge of the work must request a cable search from the Electrical Engineer who may require specific procedures to be followed. Work must not be commenced until the cable search has been investigated and the person in charge of the work advised.

WARNING

Underground cables and other services are installed by various railway entities and by other authorities or bodies. The locations of all services must be confirmed before digging etc is commenced.

4.8 Traction Return System

4.8.1 Interfering with Negative Connections to Rail

If the negative cables connecting a substation or sectioning hut to the track or to the track bonding equipment are broken or disconnected, equipment in the substation or sectioning hut could cause the cable voltage to rise to a dangerous level.

Similarly, separation from the rest of the track of a section of rail to which these cables are connected could cause the separated rail to become live at a dangerous voltage.

Broken or disconnected cables must be reported to the Electrical System Operator and any work requiring disconnection of negative cables, such as rerailing, must be coordinated with the relevant Electrical Engineer.

Appropriate bridging connections must be made when negative cables are connected or disconnected, or the 1500 volt supply must be removed and the persons involved signed on the appropriate Permit.

4.8.2 Disconnecting or Removing Sections of Rail

When sections of rail are to be removed or disconnected, allowance must be made for traction return current. This current may be the result of electric traffic on an adjacent track or may be current returning to a nearby substation from more distant electric traffic on the same track.

When a traction rail or traction bonds are disconnected in a section of electrified track beyond which there is no substation (eg. Caringbah to Cronulla), there is a danger of overhead wiring equipment or equipment on a stationary train causing the rail ends to become alive at a dangerous voltage. The relevant Electrical and Signals Engineers must be contacted to ensure that safe procedures are followed.

If it is necessary to remove the 1500 volt supply in order to make the work safe, an appropriate Permit must be issued to ensure that supply is not restored until the rails or traction bonds are reconnected.

4.9 Earthing System

4.9.1 Disconnected or Broken Earth Connections

Earth connections between equipment and the earthing system must not be removed while the equipment is in service unless it is specifically known that this can be done with safety.

If an earth or neutral connection is broken or removed from equipment that is in service, a dangerous voltage may appear on the cable connected to the equipment. Equipment that can produce dangerous voltages under these conditions includes voltage transformers and surge arrestors.

4.9.2 Substation Earth Grid Voltages and Transferred Earth Potentials

Under fault conditions substation earth grids can rise to high voltages.

Care must be taken when working on power cables, telecommunications cables and transmission lines into substations. Dangerous voltages could arise between the earth grid and the cable or transmission line conductors (including the cable sheath and transmission line earth) if a substation fault or a remote earth fault occurs during the work.

Appropriate bridging connections must be made between the equipment being worked on and the substation earth grid.

4.9.3 Earth Grid and Earth Electrodes

If part of an earthing system is separated, a voltage may appear at the break. When it is necessary to break a part of any earthing system and there is no parallel connection, jumpers of equivalent current carrying capacity must be connected across the part of the earthing system before it is broken unless all associated equipment has been isolated.

Care must be taken when reconnecting a broken earth lead.

4.10 OHW Structures

There is a possibility that overhead wiring structures may rise to a potential above earth. The risk of persons receiving an electric shock when standing beside an overhead wiring structure and touching the structure is extremely low. However persons are advised to avoid touching overhead wiring structures at the same time as they touch steel troughing, metal fences or rolling stock.

When using electric power tools on overhead wiring structures, persons must not use an earthed tool. Tools must be either battery operated, double insulated, supplied from a suitable isolating transformer, or supplied from a portable generator.

4.11 Capacitors

Capacitors store electrical energy and care must be taken when working on equipment with capacitors. Large capacitors or banks of capacitors must be discharged and proved dead prior to commencement of work. Capacitors are found in rectifiers, harmonic filters, lighting control equipment and other places. Lengths of screened or metallic sheathed cable also have significant capacitance and must be treated in the same manner.

4.12 Current Transformers

The secondary circuit of a current transformer (CT) must not be open-circuited or left open circuit while the primary circuit is live. Care must be taken when working on substation wiring especially protection relays and current transformer links in circuit breakers.

4.13 Lightning

4.13.1 General

If thunder is heard 10 seconds after a lightning flash, the lightning is only about three kilometres away. In this case seek shelter and take other precautions urgently. The shorter the time, the closer the lightning and the next strike may be closer still.

Cease touching conductors and earth wires and metal fittings.

4.13.2 If outdoors

Seek shelter in a 'hard top' vehicle or solid building - avoid small structures.

If far from shelter, crouch (alone, feet together), preferably in a hollow (avoid being the highest object). Remove metal objects from head/body (wet clothing is not a hazard and may actually reduce the degree of injury if struck).

DO NOT SHELTER UNDER TREES DO NOT LIE DOWN

KEEP AWAY FROM POLES WITH EARTH CONDUCTORS, FROM TALL METAL STRUCTURES AND FROM ISOLATED TREES.

A person working on an overhead line has an increased risk of injury from lightning due to the elevated position and the conductive line which will transfer a strike anywhere on the line to the whole length of the line including any worksite. However, earthing and short circuiting transmission lines and rail connecting the overhead wiring significantly reduces this risk.

4.13.3 Use of Telephones

There is a low risk of receiving a shock when using an automatic telephone during lightning storms. The risk occurs because the telephone exchange earth is usually different to the location earth.

During a lightning storm persons should:

- keep the call brief,
- refrain from touching electrical appliances, water pipes or metal fittings, and
- use the supervisory telephone for preference when in a substation.

4.14 Roof Equipment of Electric Vehicles

4.14.1 Pantographs

Care must be taken when it is necessary to secure or make safe a damaged pantograph of an electric locomotive or Tangara type vehicle.

On electric locomotives the two pantographs on each locomotive are electrically connected and a raised pantograph will liven a lowered pantograph. One pantograph may be isolated from the other by opening an isolating switch on or in the locomotive.

If a damaged pantograph is tied down and it is within **50mm** of the roof the pantograph isolating switch must be opened.

A Permit must not be issued for work on the roof of an electric locomotive if there is live overhead wiring above either pantograph, regardless of that pantograph being lowered and/or isolated.

On Tangara type vehicles there is a possibility that the two pantographs of the 4 car set may be electrically connected and one pantograph may liven the other of the set.

If a damaged pantograph is tied down and is within **50mm** of the roof the other pantograph must be lowered.

A Permit must not be issued for work on the roof of a 4 car Tangara set if there is live overhead wiring above either pantograph, regardless of that pantograph being lowered and/or isolated.

On other types of electric vehicles the pantographs are electrically separate and can not be livened from other pantographs.

4.14.2 Capacitors

Roof mounted capacitors must be treated as being live unless proven to be discharged.

WARNING

Procedures for electric vehicles manufactured or modified later than Tangara type vehicles may need to consider the interconnection of pantographs.

5 Locks

Access to, and operation of, electrical equipment is restricted by use of the following types of locks:

C 1	Substations.
C1A	Sectioning huts, link areas, 1500V field switches, HV field switches, low voltage main switchboard rooms and collapsible ladders to live equipment. (ie locks which prevent access to live HV equipment)
C1B	Low voltage distribution rooms (ie, locks preventing access to locations containing metalclad equipment) and selected 1500V field switches which may be operated by station staff.
D1	Traction substations and sectioning huts with external links. Signalling Equipment Power Rooms.
No. 2	Low voltage switchboards. (May also be locked with the local electricity distributor's lock).
M	Low voltage switchboards at various locations in the Northern Region.

C1 keys will unlock C1, C1A, and C1B locks.

C1A keys will unlock C1A and C1B locks.

High voltage equipment must be secured at all times either directly or by being located in a secured area.

Where it is necessary to secure a switch for the protection of personnel or equipment, the standard lock must be replaced with a special lock. A special lock may be any lock not listed above and not otherwise in general use.

Where a special lock is used, it should also secure any associated Danger Tags.

Keys for the types of locks listed above must only be issued to persons authorised for duties requiring them. Each key issuing location is required to keep a signed register of key issues.

The System Control Engineer is the nominated custodian for C and D type keys. Each key issuing location is required to obtain C and D keys from the System Control Engineer, and once issued advise the System Control Engineer to whom it was issued.

Unauthorised copies of a key for any of the above mentioned locks must not be made.