

**Engineering System Integrity
Electrical Network Safety Rules**

**Engineering Procedure
Electrical Distribution Unit**

Electrical Distribution Network Management

**PR D 78305
1500 Volt Operating Procedures**

Version 3.0

Date in Force: 3 June 2026

Approved by: Associate Director
 Electrical Distribution Unit
 Engineering System Integrity

Authorised by: Engineering Technical
 Publications Manager
 System Integrity

Disclaimer

This document was prepared for use by persons in connection with works near or on/within the rail network electricity system operated by Sydney Trains. Sydney Trains makes no warranties, express or implied, that compliance with the contents of this document shall be sufficient to ensure safe systems or work or operation. It is the document user's sole responsibility to ensure that the copy of the document it is viewing is the current version of the document as in use by Sydney Trains. To the extent permitted by law, Sydney Trains excludes any and all liability for any loss or damage, however caused (including through negligence), which may be directly or indirectly suffered in connection with the use of this document.

Copyright

The information in this document is protected by copyright and no part of this document may be reproduced, altered, stored or transmitted by any person without the prior consent of Sydney Trains.

Document control

Version	Date	Author/ Prin. Eng.	Summary of change
1.5	23 October 2020	Nick Loveday	Revisions arising from SME review
1.6	1 February 2022	ENSR Project Team	Reviewed as part of the ENSR Project.
1.7	4 February 2023	Nick Loveday	Updated Section 8 re Proving Dead.
2.0	13 March 2026	Nick Loveday	Merged EI D 26-01, EI D 23-07, EI D 22-04
3.0	3 June 2026	Nick Loveday	Corrected "Summary of Changes" and 3.3(a)i

Summary of changes from previous version

Summary of change	Section
Inserted references to NGE224, NGE228 and NPR 714.	3.1
"schedule" defined	3
Revised section 3.3(a) adding requirement to remove load before a switch is opened using the controlling circuit breaker	3.4(a)
Removed section "Danger Tags" (duplicated by text at 3.3 (b))	3.4(b)
Merged content of section 5 into section 3 and re-ordered to reflect the sequence of actions	3
Added applying special locks & DT on cages	6.6
Operation of switch pairs corrected with respect to special locks & danger tags	6.6, 6.7
Section 8.5 replaced	8.5 ... 8.5.3
Added reference to PR D 78306	8.5.1
Section 9.4 replaced with 9.2 to address breaks in OHW including those created by open switches	9.2
Merged EI D 23-07 adding new section "Temporary Bridges"	9.3
Lists reformatted throughout bullets to alpha	All

Table of Contents

1	Purpose and scope	5
2	Definitions	5
3	Operation of 1500 Volt isolating equipment	5
3.1	Switching instructions.....	5
3.2	The point of isolation.....	5
3.3	Before opening isolating equipment.....	6
3.4	Operate the equipment.....	7
3.5	The point of isolation shall be secured.....	7
4	Staged operation	7
5	Incident operation	7
6	1500 Volt isolation	8
6.1	Isolation of 1500 Volt traction sections.....	8
6.2	Sectioning switches.....	8
6.3	Sectioning switch operating procedure.....	9
6.4	Two-position combined isolating and rail connecting field switch.....	9
6.5	Two-position combined isolating and rail connecting field switch operating procedure.....	10
6.6	To isolate and rail connect the 1500 Volt overhead wiring using switch pairs.....	11
6.7	To restore supply to the 1500 Volt overhead wiring using switch pairs.....	11
6.8	Removing bridges.....	12
6.9	Rectifiers.....	12
6.10	Harmonic filters.....	13
6.11	1500 Volt positive busbar.....	13
6.12	1500 Volt withdrawable type circuit breakers.....	13
6.12.1	Background.....	13
6.12.2	Racking procedure.....	13
6.12.3	Withdrawal for work on the 1500 Volt OHW section.....	13
6.12.4	Withdrawal for work on the circuit breaker.....	13
6.13	1500 Volt switching in Fleet Maintenance Centres.....	14
6.13.1	Demarcation.....	14
6.13.2	Retractable OHW that isolates and connects to earth.....	14
6.13.3	Traction return isolating switches.....	14
7	Identifying the rail carrying traction current	14
8	Manually proving dead 1500 Volt equipment	15
8.1	Principles.....	15
8.2	Proving dead 1500 Volt cables.....	16
8.3	Proving dead for equipment inside substations.....	16
8.4	Proving dead for equipment outside substations.....	16
8.4.1	Test equipment.....	16
8.4.2	Before connecting to rail.....	16
8.4.3	Before issuing an Electrical Permit to Work.....	16
8.4.4	Measured voltage.....	17

8.4.5	Voltage < 375 V	17
8.4.6	375 V < Voltage < 600 V	17
8.4.7	Voltage > 600 V	17
8.4.8	Defects.....	17
8.4.9	Connecting test equipment	18
8.5	Working close to exposed 1500 V equipment	18
8.5.1	Electrical hazards and safety controls	18
8.5.2	Single structure or location.....	19
8.5.3	Extended or moving worksites	20
9	Rail connections.....	21
9.1	Adjacent live sections or subsections	21
9.2	Open switch or break in overhead wiring	21
9.3	Temporary bridge	21
9.4	Multiple feeders.....	22
9.5	Sectioning Hut between worksite and point of isolation	22
9.6	Rail connecting pantographs on rail mounted overhead wiring maintenance vehicles ...	22
9.7	Insulated track joints.....	22
9.8	1500 Volt positive feeders (cable or aerial) originating from substations or section huts	22
9.9	Equipment within a substation	23
9.10	Methods of rail connecting	23
9.11	Rail connection methods.....	24
9.12	Portable rail connections	24
9.12.1	Rail connection procedure.....	24
9.12.2	Removing rail connections.....	26
9.13	Temporary rail connections	27
9.13.1	Arrangement of temporary rail connections	27
9.13.2	Installing and removing temporary rail connections	27
9.13.3	Installing temporary rail connections	27
9.13.4	Removing temporary rail connections	28
9.14	Equipment subject to fault currents	28
10	Approved equipment	29
11	Referenced documents	29

1 Purpose and scope

This procedure describes the operating procedures that are applicable to the 1500 VDC Traction network, which includes:

- a. Configuring the system (Switching)
- b. Proving dead
- c. Applying 1500 Volt Rail connections.

2 Definitions

Refer to the **Electrical Safety Definitions** page available on the **RAILSAFE** site.

3 Operation of 1500 Volt isolating equipment

3.1 Switching instructions

All isolating devices shall be operated under the direction of the ESO and agreed with the Authorised Person undertaking the switching operation. Switching operations shall be performed in accordance with a “**schedule**” defining the equipment, the action to be performed and its “to be” state. The schedule may be in the form of either:

- a. A 1500V Authority, or
- b. A Switching Plan (in substations), or
- c. A sequence received verbally from an ESO and recorded in writing by the Authorised Person.

All communications between the ESO and the Authorised Person shall be in accordance with *NGE 204 Network Operations* and *NPR 721 Spoken and written communication*. The ESO shall instruct the Authorised Person:

- a. Which isolating device is to be operated, and
- b. The operation to be undertaken.

The Authorised Person shall confirm these instructions match the schedule.

NOTE:

If the Authorised Person is delayed from operating the equipment the Authorised Person shall inform the ESO. If operating the switch for isolating purposes, the switch shall be Danger Tagged. Refer to *PR D 78104 Securing Systems for Electrical Equipment* and for individual cases refer to the Equipment Local Instruction.

3.2 The point of isolation

1500 Volt equipment shall be isolated from all sources from which it could be made live, by providing at least one visible break in each source,

AND

The effectiveness of the isolation shall be demonstrated by a visible break, or where it is not practicable to demonstrate a visible break, then in accordance with the

approved Equipment Local Instruction or as set out in Section 6 for the equipment.

When an isolating device can also be operated by remote control, the remote control shall be made inoperative and the means of ensuring that it remains inoperative shall be Danger tagged.

WARNING

An open circuit breaker is not a sufficient isolating break.

Either the circuit breaker shall be racked out, or the associated switch or links opened.

3.3 Before opening isolating equipment

Where practicable, the person preparing to operate isolating equipment should confirm devices are not carrying load before opening the equipment.

WARNING

Opening isolating equipment under load may cause severe and dangerous arcing, damage to the equipment or serious injury to the operator.

Prior to operating isolating equipment, the Authorised Person shall:

- a. EITHER
 - i. For sectioning switches used to isolate the source of supply, confirm the circuit breaker supplying the 1500V switch is in the open state and has been secured in accordance with the Local Instructions for that equipment before opening the switch.

OR

- ii. For sectioning switches used to isolate adjacent 1500 OHW sections, contact the ESO and confirm the load has been removed. The ESO shall confirm electric rolling stock:
 - Cannot enter the section, and
 - Have left the section, or
 - Rolling stock in the section have been stabled with the pantographs down.

AND

- b. Check whether there is a Danger Tag on the equipment. In this event the Authorised Person shall inform the ESO and await further advice from the ESO.

WARNING

An isolating device with a Danger Tag must not be operated.

- c. Confirm the isolating device is the correct one by checking the location and the label on the isolating device matches that on the schedule;
- d. Confirm the equipment is in the expected position per the Electrical Operating Diagram (open, closed, racked in or racked out). In the case of a switch, this shall be done by checking the positions of both the blade and handle. If the equipment is not in the expected position the Authorised Person shall inform the ESO and await further advice from the ESO.

3.4 Operate the equipment

If the equipment is in the expected state and no Danger Tag present, or advised to proceed by the ESO, the Authorised Person shall then (as appropriate):

- a. Prove dead (note: proving dead is not required before moving a two-position isolating and rail connecting switch into the “TO RAIL” position)
- b. Remove the Standard Lock,
- c. Operate the Equipment as per the Local Instructions or as set out in Section 6;
- d. Secure the equipment; and
- e. After the required operation has been carried out, the Authorised Person shall advise the ESO of the operation that has been carried out.

3.5 The point of isolation shall be secured

The isolating device that provides the isolation break shall be secured in accordance with PR D 78104 for the duration of the isolation.

The equipment shall be secured with a Danger Tag and Special Lock for the duration of an isolation to prevent inadvertent operation of the equipment:

- a. Where it is not inside a secure location (substation or sectioning hut), or
- b. Where the isolating device has facilities for locking, and provided that the action of locking does not bring the Authorised Person within the minimum Safe Approach Distances (SAD) of exposed electrical equipment as specified in *PR D 78700 Working around Electrical Equipment*.

NOTE:

Jumpers that have been removed to effect isolation are not required to be Danger tagged or locked.

4 Staged operation

Isolating equipment that has an intermediate position or is mechanically interlinked may be secured in the open position, with a special lock and Danger Tag in preparation for operating the switch to the ‘To-Rail’ position.

5 Incident operation

In a life-threatening situation:

- a. It is permissible to move the isolating equipment from the ‘CLOSED’ position to the “OPEN” position without first proving dead:
 - After ALL circuit breakers (feeders and rectifiers) connected to the 1500 Volt bus-bar are opened by SCADA prior to the switch being opened, and
 - When instructed by an ESO at ICON Electrical.
- b. It is permissible to move the isolating equipment from the ‘OPEN’ position to the ‘To-Rail’ position without first proving dead:
 - The 1500 Volt overhead wiring section concerned has been isolated, and
 - When instructed by an ESO at ICON Electrical.

6 1500 Volt isolation

6.1 Isolation of 1500 Volt traction sections

Isolation of the 1500 Volt Traction sections/subsections in accordance may be achieved using the following isolating devices:

- a. Opening Sectioning Switches (refer Section 6.2...6.3)
- b. Operating Two-Position Combined Isolating and Rail Connecting Field Switches (refer to Section 6.4...6.5)
- c. Operating Three-Position Combined Isolating and Rail Connecting Switches (Edward Keller), refer to *EL D 81020 EDWARD KELLER/ART 1500VDC – 3000A Isolator Equipment Operation*
- d. Operating Isolating and Rail Connecting Switch Pairs (refer to Section 6.4...6.5)
- e. Operating a Remote Isolating and Rail Connecting (RIRC) switch (refer to *EL E 81064 Remote Isolation and Rail Connecting (RIRC) Switch (Infraco)*)
- f. Removing 1500 Volt Withdrawable Type Circuit Breakers (refer to Section 6.12)
- g. Removing bridges (refer to Section 6.8).

Isolating equipment must be operated in accordance with the schedule, Local Instructions or as set out as follows.

6.2 Sectioning switches

Sectioning switches are used to isolate a section of the 1500 Volt overhead wiring (OHW) from another section or from an aerial or cable feeder.

Sectioning Switches may be hand lever or motor operated. They are of a pivoted blade construction and have two positions, labelled "CLOSED" and "OPEN".

Table 1: Pivoted blade switch positions

State of electric circuit through switch	Switch position
Continuous	"CLOSED"
Broken	"OPEN"

Sectioning switches are hand-lever (manual) or motor-operated.

Hand lever operated switches are fitted with a locking pin for locking the switches in either position. The locking pin shall be secured by the appropriate lock (refer PR D 78104).

Motor-operated switches shall be secured by the appropriate lock (refer PR D 78104).

6.3 Sectioning switch operating procedure

Hand lever type

The Authorised Person shall:

- a. Remove the padlock and locking pin from the switch-operating handle. Where required, use the locking pin to secure the sections of the handle.
- b. Move the switch handle to the required position with a single unhesitating movement.
- c. Check that the switchblade has moved to the required position.
- d. Insert the locking pin in the switch handle and lock the switch in the required position

NOTE:

If operating the switch for isolating purposes, the switch shall be Danger Tagged, refer to Section 3.3.

Motor operated type

There are three methods of operation for this type of Sectioning Switch:

- a. Remotely controlled electrical operation.
- b. Locally controlled electrical operation.
- c. Manual operation.

The procedures for operating the motor operated switch are documented in the Local Instructions, which are available in the switch cabinet.

- a. Movement of the switch between the “OPEN” and “CLOSED” positions (either direction) is by motor operation under remote or local control. Movement between these positions is normally controlled remotely by the ESO. Remote control is disabled by selecting local control. Manual operation can be used when motor operation is not available.
- b. Where a locking device is located inside the cabinet, it should be used to secure and padlock the switch in the “OPEN” position. The locking device operates an auxiliary switch to disable the motor.

NOTE:

When supply is being restored, a remotely controlled switch shall be operated by the ESO.

6.4 Two-position combined isolating and rail connecting field switch

Two-position combined isolating and rail connecting field switches are installed at various sidings and terminating roads to enable the 1500 Volt OHW section that is switched to be isolated and rail connected.

This type of switch is used only when it is the single source of 1500V supply to a subsection, such as in a siding or terminating road.

The switch has a pivoted single blade construction, is operated by a hand lever and has two positions labelled "CLOSED" and "TO RAIL".

Some types of switch prevent the movement of the blade directly from one position to the other, by means of an intermediate stop position in the hand lever mechanism.

Another type of switch has a pivoted two blade construction, having a compound action that causes the isolating blade to move from the “CLOSED” position to an isolated position before the rail connecting blade moves to the “TO RAIL” position. This operation is reversed during the restoration of supply, when this switch is operated from the “TO RAIL” position to the “CLOSED” position.

Table 2: Pivoted two blade switch positions

State of OHW Section	Switch position
Live	"CLOSED"
Isolated at that location	Intermediate (See Note below)
Rail connected at that location	"TO RAIL"

NOTE:

The switches cannot be locked in the intermediate position and shall not be left in this position. The intermediate position is not labelled.

Two-position combined isolating and rail connecting field switches are fitted with a pin for locking the switches in either position. The locking pin is secured by padlock.

6.5 Two-position combined isolating and rail connecting field switch operating procedure

Prior to operating the switch, the Authorised Person shall check that the rail connecting cables are connected to rail. This should be done by:

- a. An end-to-end visual inspection, or
- b. By testing from the rail connecting jaw using the LR Tester.

To operate the switch, the Authorised Person shall:

- a. Remove the padlock and locking pin from the switch handle. Where required, use the locking pin to secure the sections of the hinged type handle.
- b. Move the switch handle to the intermediate stop position with a single unhesitating movement.
- c. Check that the switch blade has moved to the isolated position.
- d. Move the switch handle horizontally and then to the required position.
- e. Check that the switch blade has moved to the required position.
- f. Insert the locking pin in the switch handle and lock the switch in the required position, and
- g. Danger tag the switch (refer to Section 3.3).

Proving dead is not required before moving this type of switch into the “TO RAIL” position.

6.6 To isolate and rail connect the 1500 Volt overhead wiring using switch pairs

The following procedure describes the situation where the Authorised Person at a location can commence and complete the isolation and rail connection process at that location without having to leave the location concerned.

WARNING

The isolating switch shall not be opened before its controlling circuit breaker has been opened. Opening the switch under load may cause severe and dangerous arcing.

When advised by the ESO that the isolating switch is to be opened, the Authorised Person shall:

- a. Operate the isolating switch from the "CLOSED" to the "OPEN" position with a single unhesitating movement.
- b. Apply a Special Lock and Danger tag at the switch where practicable or on the cage.
- c. Check that the isolating switch blade has moved to the "OPEN" position.
- d. Advise the ESO the switch is in the "OPEN" position.

When advised by the ESO that proving dead and rail connecting switching is to proceed, the Authorised Person shall:

- a. Prove dead the fixed top 1500 V contact of the rail connecting switch in accordance with approved procedures.
- b. Operate the rail connecting switch from the "OPEN" to the "CLOSED" position.
- c. Check that the rail connecting switch blade is in the "CLOSED" position.
- d. Move the Special lock to the cage above the isolating switch lever pin.
- e. Advise the ESO the rail-connecting switch has been operated to the "CLOSED" position and Special Lock and Danger Tag have been applied.

6.7 To restore supply to the 1500 Volt overhead wiring using switch pairs

The following procedure describes the situation where the Authorised Person at a location can commence and complete the restoration process at that location, without having to leave the location concerned.

When advised by the ESO that the rail-connecting switch is to be operated from the "CLOSED" to the "OPEN" position, then the Authorised Person shall:

- a. Relocate the Special Lock and Danger Tag on the cage of the switch lever pin
- b. Operate the rail-connecting switch from the "CLOSED" to the "OPEN" position.
- c. Check that the rail-connecting switch blade has moved to the "OPEN" position and
- d. Advise the ESO that the rail-connecting switch is in the "OPEN" position.

When advised by the ESO the isolating switch is to be operated from the “OPEN” to the “CLOSED” position, the Authorised Person shall:

- a. Remove the Special Lock and Danger Tag,
- b. Operate the isolating switch from the “OPEN” to the “CLOSED” position with a single unhesitating movement
- c. Confirm that the isolating switch blade has moved to the "CLOSED" position, and
- d. Advise the ESO of the switch position.
- e. Apply a Danger Tag to the isolating switch (refer to Section 3.3).

6.8 Removing bridges

Where bridges are to be removed to isolate a portion of overhead wiring or cable, any free ends shall be secured to avoid contact with other conductors, structures, masts, guy arrangements or earth, etc.

6.9 Rectifiers

To isolate a rectifier, the following steps shall be carried out whilst ensuring that no person comes within the minimum SADs:

- a. Isolating the High Voltage supply to the rectifier transformer.
- b. Racking out the DC circuit breaker or opening the positive link.
- c. Opening the negative link.
- d. Isolating the Low Voltage AC and DC supplies as required.

WARNING

The negative link shall not be opened before the DC circuit breaker is racked out or the positive link is opened. The negative link shall be closed before the DC circuit breaker is racked in or the positive link is closed.

WARNING

Rectifiers contain capacitors that shall be isolated and discharged in accordance with Local Instructions or PR D 78102 Electrical Hazards and Warnings Section 10 Capacitors, and then proved dead prior to the commencement of work.

WARNING

Ensure capacitors are isolated, completely discharged (for at least 5 minutes) and ‘Tested before Touched’ prior to working on the equipment.

6.10 Harmonic filters

Harmonic Filters shall be isolated by opening the link or switch connecting the filter to the 1500 Volt positive busbar and opening the link in the connection to the negative busbar when a link is provided.

WARNING

Harmonic Filters contain capacitors that shall be isolated and discharged in accordance with Local Instructions or PR D 78102 Section 10 Capacitors, and then proved dead prior to the commencement of work.

WARNING

Ensure capacitors are isolated, completely discharged (for at least 5 minutes) and 'Tested before Touched' prior to working on the equipment.

6.11 1500 Volt positive busbar

When a 1500 Volt positive busbar is isolated for work, the harmonic filter shall be considered as a source of supply and shall be discharged or isolated from the bus bar.

6.12 1500 Volt withdrawable type circuit breakers

6.12.1 Background

At some substations and sectioning huts, isolation of 1500 Volt OHW sections is carried out by the racking out of the controlling circuit breakers. In such instances, the relevant circuit breakers shall be Danger Tagged.

6.12.2 Racking procedure

The Authorised Person shall carry out the procedure to rack out or rack in the circuit breaker as set out in the Local Instruction held at the substation or sectioning hut.

6.12.3 Withdrawal for work on the 1500 Volt OHW section

To ensure adequate isolation of the 1500 Volt OHW section, the controlling circuit breaker should be racked out a distance of at least 300 mm. This may generally be achieved if the front truck wheels of the breaker frame are clear of the cubicle.

6.12.4 Withdrawal for work on the circuit breaker

For work on withdrawable type circuit breakers, the:

- a. Circuit breaker shall be fully withdrawn
- b. Low Voltage control-wiring plug shall be removed.
- c. The Low Voltage control wiring plug may be reinserted for testing purposes.

Whilst the circuit breaker is fully withdrawn, a special barrier shall be placed across the circuit breaker cubicle opening to prevent access to live 1500 Volt equipment.

6.13 1500 Volt switching in Fleet Maintenance Centres

6.13.1 Demarcation

1500 V isolations within Electric Vehicle Maintenance Centres (EVMC) are implemented either:

- a. For the purpose of safe access to maintain rolling stock, by Fleet Maintenance in accordance with their procedures;

or

- b. For all other purposes by Sydney Trains Network Maintenance, using the Electricity Network Safety Rules.

6.13.2 Retractable OHW that isolates and connects to earth

Where the facility includes a retractable OHW which has been moved to the retracted position the rails, building and retractable OHW are considered connected to rail via the rail/earth switch.

6.13.3 Traction return isolating switches

Where the facility includes a traction return isolating switch ensure the track beneath the worksite remains at rail potential by confirming the location of the rail insulating joint and either:

- a. Ensuring the dead leg of the traction rail is connected to the building earth, or
- b. Implementing an appropriate rail bonding arrangement.

Where the facility includes a retractable OHW which has been moved to the retracted position the rails, building and retractable OHW are considered connected to rail via the rail/earth switch.

7 Identifying the rail carrying traction current

When proving dead 1500 Volt OHW whilst working on track or when applying portable rail connection on track, this procedure requires the identification of the rail carrying traction current.

At steel masts with spark gaps, the traction rail is the rail to which the steel masts are bonded.

For all other cases, e.g. wood pole construction or steel construction with missing bonds, a representative of the Signal Discipline shall identify the Traction Rail.

WARNING

Care shall be taken when applying rail connections so that they do not short circuit rails and affect signal operation.

WARNING

Care shall be taken to ensure that rail connections are not made to portions of rail that are, or will become, disconnected from the traction return path as a result of the work.

8 Manually proving dead 1500 Volt equipment

8.1 Principles

WARNING

Although electrical equipment or a section of OHW is ‘dead’ or de-energised, this does not mean that the equipment or the section of the OHW is safe to work on (“touch safe”).

When it is necessary to manually prove 1500 V equipment is not connected to a source of supply – “dead”, this shall be performed with approved test equipment (refer SP D 79039).

NOTE:

The test equipment should (where practicable) be checked immediately prior to proving dead, and at the completion of the test to confirm the tester is functional throughout the proving-dead test. This should be done by testing known-live 1500V equipment, or operating the self-test function (if the equipment has this function).

Prior to coming within the Safe Approach Distance (SAD), the 1500 Volt equipment shall be:

- a. Isolated for work, and other end of the 1500 Volt Overhead Wiring section concerned has been isolated,
- b. Proven dead using approved Test Equipment,
- c. Rail connected where appropriate.

For discrete items of Substation equipment, Local Instructions shall be followed concerning proving dead procedures.

Where equipment has designated test points these shall be used.

For 1500 Volt OHW, proving dead shall be performed immediately prior to rail-connecting to ensure that rail connections can be safely applied. However, proving dead may also be required at additional times during the progress of the work.

For proving safe to apply rail connections or safe to touch the appropriate approved 1500 Volt testers per *SP D 79039 Electrical Tools and Test Equipment* must be used:

- a. Test point connected to Traction Overhead Wiring – Low Impedance Voltage Tester
- b. Test point not connected to Traction Overhead Wiring – High Impedance Voltage Tester.

8.2 Proving dead 1500 Volt cables

Prior to work, 1500 Volt d.c cables shall be isolated and proven dead at cable/exposed equipment junctions.

NOTE:

1500 Volt d.c cables shall not be proved dead by spiking.

Before cutting an isolated 1500 Volt d.c cable at a worksite that is remote from the worksite location where the cable was proved dead, it shall be identified as the proved-dead cable at the worksite by two independent methods. Identification methods include, but are not limited to:

- a. Visual tracing,
- b. Using of an electronic cable tracing device, or
- c. Reference to labelling on the cable or the cable enclosure.

8.3 Proving dead for equipment inside substations

1500 Volt equipment inside a substation shall be proven dead with respect to an appropriate negative connection, e.g. rectifiers, 1500 Volt busbars and harmonic filter components such as capacitors.

The capacitors of harmonic filters shall be proved-dead to confirm that they have been discharged.

8.4 Proving dead for equipment outside substations

8.4.1 Test equipment

Sections of the 1500 Volt OHW system that have been isolated for work shall be proven dead using the appropriate Approved Test Equipment immediately prior to applying rail connections. The test equipment is used to determine if a section of the 1500 Volt OHW system:

- a. is live or dead,
- b. after isolation is safe to rail connect, and
- c. is safe to work on with an Electrical Permit.

8.4.2 Before connecting to rail

A conductor shall not be rail connected unless:

- a. the conductor has been isolated,
- b. the Voltage measured is less than 375 Volt d.c.

8.4.3 Before issuing an Electrical Permit to Work

A conductor shall not be considered safe to work on unless:

- a. the conductor has been isolated, rail-connected, is included in the Safe Work Area defined by an Electrical Permit to Work, and
- b. the Voltage measured was less than 50 Volts d.c.

8.4.4 Measured voltage

Based on the measured voltage the Authorised Person shall proceed as per Table 3.

Table 3: Action

Measured Voltage	Action
> 600 V	Report to ESO and seek advice.
> 375 and ≤ 600 V	Obtain 2 nd Hivotech Tester and simultaneously prove dead at same location. Inform the ESO if a delay will be incurred while obtaining another tester. If voltage measured on both testers is > 375 V, inform the ESO and seek advice. If voltage measured on both testers is ≤ 375 V, proceed with rail connection, report to the regional engineer during business hours.
≤ 375 V	If conductor is isolated, proceed with rail connection where required.
≤ 50 V	If conductor is isolated, rail-connected, is included in the Safe Work Area defined by an EPTW, then conductor is safe to work on.

8.4.5 Voltage < 375 V

If the voltage measured is less than 375 V then rail connecting may proceed without further direction from ESO at ICON Electrical.

8.4.6 375 V < Voltage < 600 V

In the event the measured voltage is in the range 375 V to 600 V, the Authorised Person shall obtain a second Hivotech tester and simultaneously prove dead using both testers at the same location. Note that with both Hivotech testers in parallel they will have similar readings. If the voltage measured on both testers is greater than 375 V this shall be reported as a defect to the ESO and their advice sought prior to the application of rail connections on the OHW sub-section concerned. The ESO will proceed as described at Section 8.4.7.

8.4.7 Voltage > 600 V

In the event the voltage reads more than 600 V this shall be reported as a defect to the ESO and their advice sought prior to the application of rail connections on the OHW subsection concerned. The ESO will proceed as described at Section 8.4.8.

8.4.8 Defects

When advised of a defect, the ESO will inform the regional maintenance engineer. The regional maintenance engineer will:

- a. Record a defect for the OHW section concerned.
- b. Carry out an inspection of the OHW as soon as practical in accordance with insulator inspection requirements contained in Service Schedules E08014 (for

open track), E08032 (for tunnels) and E08012 (for section insulators) for those insulators separating different electrical sections to identify the degraded insulation.

- c. Carry out all actions necessary to remove the defect.

The technical maintenance plan shall be updated to reflect the inspection.

8.4.9 Connecting test equipment

The rail to be utilised for the proving dead process is the Traction Rail (refer to Section 4) associated with the section of 1500 Volt OHW to be isolated, rail connected and worked on. Should that particular Traction Rail not be available, i.e. a section of rail has been removed, the Traction Rail of the nearest adjacent track can be utilised as the Traction Rail; and hence connected to the rail connection lead (negative return) of the Approved Test Equipment for the proving dead procedure.

Should an associated/adjacent Traction Rail not be available for the prove dead procedure then the Authorised Person is to prove dead the 1500 Volt OHW section to be worked on by visual tracing of the 1500 Volt OHW from another location where the prove dead test procedure can be successfully completed.

WARNING

An OHW supporting structure or earth stake shall not be utilised for connection to the rail connection lead (negative return) of the Approved Test Equipment.

8.5 Working close to exposed 1500 V equipment

8.5.1 Electrical hazards and safety controls

When working in the vicinity of exposed 1500 V equipment the hazards include:

- a. Contact with 1500 V, for example by working outside the limits of the safe work area defined on an Electrical Permit, or making contact with a structure which is at a hazardous potential as a result of a broken or damaged insulator.
- b. Electric shocks from touch potentials between different metallic objects that are not electrically connected and are within 2 m of each other. In this situation, if a person forms a contact with two metallic items at different potentials an electric shock may be felt. For example, working on the underside of an overbridge or roof of a tunnel, while standing on a scaffold or EWP. In this situation the top level of the scaffold (handrails and floor) will be at the potential of what the scaffold or EWP is standing on (ground or rail) while the OHW and the underside of the overbridge or roof tunnel will be at different potentials.

WARNING

If the OHW has not been tested and proven dead or visually traced from a set of rail connections, the OHW shall be considered live.

The safety controls that must be applied are:

- a. To work within the SAD of any exposed 1500V equipment you must work with an Electrical Permit.
- b. Where the worksite involves multiple structures – for example working on an EWP moving from one structure to another – each structure must be tested and proven dead (refer PR D 78306) before persons come closer than the Safe Approach Distance.
- c. To provide protection from touch potentials:
 - i. Test the potential voltages between the items; if proven dead (refer [PR D 78306](#)) proceed; otherwise obtain advice from the regional Electrical Engineer, and

AND either:

- ii. Apply temporary bonds, spark-gaps or portable rail-earth contactors (REC) to ensure the potential differences between metallic items remain safe (i.e. less than 50 V).

OR

- iii. Apply insulation covering exposed metallic items, so that a person cannot form a circuit between two or more exposed items. It is understood that the metallic structure being worked on (e.g. a rail, OHWS, overbridge or the roof of a tunnel) will remain exposed. The insulation should be nominally rated for 600 V d.c (or higher), and examples include rubber mats, insulated gloves, electrical tape, or PVC conduit. Attention should be paid to exposed metallic items within 2m of each other.

- d. Wear PPE, including insulating gloves and safety boots.

NOTE:

Only a Low Impedance 1500 Volt DC OHW Tester per SP D 79039 may be used for testing when working from an Elevating Work Platform, Bucket or Ladder.

WARNING

When working from an Elevating Work Platform, bucket or ladder, an insulated operating stick shall be used when using the Hivotech 1500 Volt DC OHW Tester.

8.5.2 Single structure or location

Where the safe work area:

- a. Includes no more than one single physically and mechanically continuous structure supporting either live or dead sections of OHW (e.g. staunchions, bridges or pedestrian bridges) forming a single electrically continuous structure, and
- b. Has no section insulator, pennant insulator or air gap within 300 m of the limits of the safe work area, and
- c. Has no live exposed equipment on the structure, and
- d. The worksite does not move or relocate, and
- e. No live adjacent tracks.

The test for dead will be performed as part of the procedure to obtain and work with an Electrical Permit. If this method of working is adopted the person in charge of the work must submit details of the proposed work to, and obtain a statement of “no objection” from either:

- a. An Authorised Traction Operator, or
- b. Authorised Officer Mains, or
- c. Sydney Trains’ Electrical Engineer.

8.5.3 Extended or moving worksites

Where either:

- a. A section insulator, pennant insulator or air gap is within 300 m of the limits of the safe work area, or
- b. The safe work area spans more than one single structure supporting either live or dead sections of OHW (e.g. staunchions, bridges or pedestrian bridges), or
- c. The worksite location has moved, or
- d. There is a live track adjacent to the worksite,

Then:

1. The Permit Holder shall check the location is within the safe work area defined in the Permit.
2. In addition to the procedures to obtain and work with an Electrical Permit the test shall be performed:
 - a. Prior to ascending from track level in an elevated work platform (EWP), bucket or ladder up to OHW height, i.e. the OHW and associated equipment shall be tested and proven dead, or
 - b. If any section insulator, pennant insulator or air gap is to be passed when working from an EWP, bucket or ladder, i.e. the OHW and associated equipment on the other side of that insulator or air gap shall be tested and proven dead.
 - c. Before working at less than the electrical SAD from any mid-track insulator or section insulator, i.e. the OHW and associated equipment on the other side of that insulator shall be tested and proven dead.
 - d. Before working at less than the electrical SAD from any OHW or associated equipment located over an adjacent track to that which the EWP, bucket or ladder is located on, i.e. the OHW and associated equipment over the other track shall be tested and proven dead.

9 Rail connections

9.1 Adjacent live sections or subsections

A rail connection shall be applied between the worksite and each point of isolation. If there is a live section or subsection of OHW adjoining the section/subsection to be rail connected such that a pantograph could bridge between live and rail connected OHW, then the rail connections shall be placed as close as possible to the points of isolation. This is to ensure the quick and proper operation of the protection equipment should faults occur between the live and rail connected sections.

Additional rail connections shall be applied, if necessary, to ensure that each section of the overhead wiring is rail connected on both sides of the worksite, except for:

- a. Dead-end sidings
- b. Electric Vehicle Maintenance Centres where special instructions apply.

9.2 Open switch or break in overhead wiring

If the OHW will become discontinuous during the course of work, the OHW on each side of each break shall be connected to rail. This includes breaks created by opening switches, as well as any discontinuity in the OHW.

Alternatively, temporary connections between the sections shall be made prior to the work ensuring the OHW remains electrically continuous.

This shall be implemented by:

- a. Operating rail connecting links or switches (preferred, where available), or
- b. Applying Portable Rail Connections to the section(s) not connected to rail.

These measures are necessary to protect persons against a difference in remote rail potentials transferred to the worksite and persons being exposed to touch potentials.

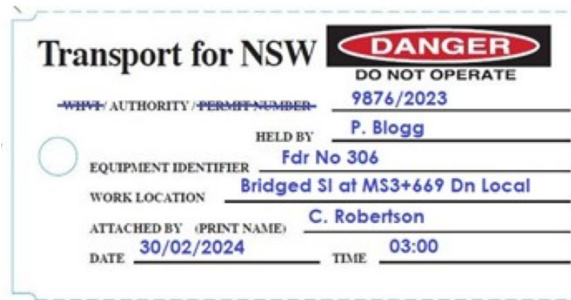
9.3 Temporary bridge

In the situations where the installation of a portable rail connection is not feasible, a temporary bridge cable should be installed to connect the sections on either side of the break in OHW to ensure continuity of the rail connection.

A temporary bridge cable may only be used to connect sections on either side of a break (i.e., Section Isolator or air gap) provided:

- a. Prior written consent has been obtained from the Associate Director EDU to use a bridge cable at this location.
- b. The location of the temporary bridge installation is less than 100m from the traction substation or Section Hut.
- c. Once clearance from the ESO has been given to the Authorised Person (Mains) in charge of the isolation they may proceed with proving dead and installing rail connections where required, prior to issuing permits.
- d. Before installing the bridge cable between two different sections of OHW the sections either side of the break shall be tested and confirmed to be de-energised.

- e. The bridge cable shall be clamped to the OHW conductors on either side of the break ensuring personnel do not encroach the SAD's by using insulated tools.
- f. The full length of the bridge cable must be located above the OHW conductor to ensure it is not caught on plant or vehicles passing under, e.g. track machines.
- g. A Danger Tag shall be applied to the switches associated with the 1500 V OHW sections that have been bridged together, for example:



- h. The bridge shall be noted on the Portable Rail Connection/Earthing Schedule (PR D 78501 FM02).
- i. Once the work is complete and the Electrical Permit to Work has been surrendered the bridge cable shall be removed, including the Danger Tags and noted on the Portable Rail Connection Schedule.

9.4 Multiple feeders

Multiple feeders to a section of OHW from the one substation that attach at different locations (for example at a junction) are to be treated as separate sources of supply. Rail connections shall be applied between the worksite and all sources of supply.

9.5 Sectioning Hut between worksite and point of isolation

Where there is a Sectioning Hut between the worksite and a point of isolation, rail connections shall be applied to each section/subsection concerned at the Sectioning Hut or between the worksite and the Sectioning Hut.

9.6 Rail connecting pantographs on rail mounted overhead wiring maintenance vehicles

The rail connecting pantograph of a rail mounted OHW maintenance vehicle, where fitted, shall be raised if the wire is 'runnable' and it is otherwise practical to do so.

9.7 Insulated track joints

Rail connections shall not cause insulated track joints to be short-circuited via the OHW.

9.8 1500 Volt positive feeders (cable or aerial) originating from substations or section huts

When working on 1500 Volt positive feeders (cable or aerial) originating from Substations or Sectioning Huts, the OHW end of the feeder shall be rail connected.

The Substation or Sectioning Hut end of the feeder should be rail connected if switches or links are provided and it is otherwise practicable.

When working on a cable feeder and the work may result in persons or equipment bridging between the core and the screen, the Rail Earth Contactor (REC) shall also be closed for the duration of the work.

9.9 Equipment within a substation

For work on 1500 Volt equipment within a Substation it is not necessary to rail connect the equipment except in the case of feeders extending outside the Substation. In this case, only the OHW to which the feeder is connected shall be rail connected as close as practicable to the worksite. (Refer to *PR D 78301 Removal and Restoration of 1500 Volt Supply*.)

The REC shall also be closed for the duration of work on a cable feeder if the work may result in persons or equipment bridging between the core and the screen.

9.10 Methods of rail connecting

Prior to rail connecting, each section/sub-section of the OHW which is to be rail connected shall be isolated and proved dead.

Rail connecting shall be carried out by either:

- a. The operation of rail connecting links or switches
- b. The application of portable rail connection equipment.
- c. The installation of temporary rail connections.

Where rail connecting links or switches are provided, they shall be used in preference to portable rail connection equipment and temporary rail connections.

NOTE:

Exception: Portable rail connection equipment shall be used in situations where work is to be carried out on the rail connecting links or switches which requires the rail connecting links or switches to be opened.

Switches used to rail connect 1500 Volt equipment shall be secured with a Special Lock and a Danger tag applied.

WARNING

In order to prevent an undesirable electrolysis situation, overhead wiring 'dead legs' or 'pennants' which, by design, are directly connected to an OHW structure (i.e. without insulation) shall not be rail connected to the traction rail for an extended period of time as the 'dead leg' or 'pennant' is earthed via the overhead wiring structure.

Unless working in accordance with *PR D 78702 Stringing of 1500 Volt OHW Conductors in the Vicinity of Existing Electrical Equipment*), rail connected overhead wiring shall not be connected to an earth stake or electrode.

9.11 Rail connection methods

This section provides a guide to selecting the appropriate method of rail connection. Use the table below to select the particular type(s) of rail connection for a particular application.

Rail Connection Application	Minimum Requirement
Daily/Week-End Isolations – with no requirement for traction return current via rail connected OHW.	Rail connecting switches and Portable rail connection equipment
Any isolation with a requirement for traction return current via rail connected OHW.	Rail connecting links or switches and or Portable rail connection equipment supplemented by Temporary rail connections as required by the Electrical Engineering Manager.
Isolations where long sections of rails (> 200m) are removed – Traction return current via rail connected OHW.	Rail connecting switches and/or Temporary rail connections

The above table represents the minimum requirement.

Alternative connection methods that differ from the minimum requirements described in the table above shall be approved by the Regional Electrical Engineer.

Approved alternative arrangements may be substituted if convenient. For example:

- a. An arrangement which is mandatory where a requirement exists to carry traction return currents may be used where no such requirement exists.
- b. An arrangement that is mandatory for a longer time may be used for a shorter time.

9.12 Portable rail connections

Approved portable rail connection equipment is identified in SP D 79039.

WARNING

Portable bridging equipment shall not be used at feeding air gaps, to provide continuity of rail connection between sections. Portable rail connections shall be used and noted on the schedule.

9.12.1 Rail connection procedure

Portable rail connections shall only be applied at the point of the 1500 Volt OHW that has been proved dead immediately prior to rail connecting. The rail connections shall be applied strictly in the following order:

- a. Inspect the equipment for no defects, and the condition of the clamp itself to ensure there is no deterioration, overheating or discharge mark (Figure 1, next page):



Figure 1: Condition of a good clamp

- b. Verify that a 'Defect/Danger' tag is not attached to the equipment and the equipment is in a serviceable condition.
- c. Verify the inspection label indicates the equipment is still within the next due inspection date.
- d. Check that the cable connections on the OHW connection clamp and the rail clamp are tight.
- e. Attach the OHW connection clamp to the insulated stick.
- f. Inspect the condition of the rail, and report any suspected damage, or abnormal condition to the track discipline representative. Proceed if all is OK.
- g. Remove the ballast underneath the rail to ensure that the rail connection clamp can be properly fitted.
- h. Connect the rail clamp to the outside of the foot of the Traction Rail, or to the stud that is attached to the rail for that purpose.

Where the rail connection is made to the second rail, the cable shall be run under both rails.

Refer to Section 7 for identification of traction rail. In audio frequency track circuit areas, connect the cable to the point nominated by the Signals Discipline.

- i. Ensure that the clamp is fully, rather than partially engaged onto the rail. Refer to photos following.



Figure 2: Fully engaged clamp



Figure 3: Partially engaged clamp (no good)

- j. Tighten the clamp onto the rail firmly and check the firm connection by pulling it to ensure that it does not come loose.
- k. Connect the OHW connection clamp to the contact wire. This shall be done by drawing the hooked section of the clamp firmly and smartly onto the contact wire. The person applying the rail connections shall maintain the SADs from other conductors to which rail connections are not to be applied, as specified in PR D 78700.
- l. Tighten the OHW connection clamp by rotating the insulated stick in a clockwise direction.
- m. Detach the insulated stick from the OHW connection clamp. If the track is to be available for non-electric train running, the cable shall be secured clear of rolling stock. The cable connection plate of the OHW clamp shall be positioned in the same direction as the cable when the cable is to be secured clear of the track.
- n. Where possible, the portable rail connection shall be secured to the OHW structure, or other suitable structure, clear of the track to permit the clear passage of diesel hauled trains and work trains.

9.12.2 Removing rail connections

The 1500 Volt OHW to rail connections shall be removed strictly in the following order:

- a. Detach the portable rail connection from the OHW structure, or other applicable structure.
- b. Attach the insulated stick to the OHW connection clamp.
- c. Loosen the OHW connection clamp by rotating the insulated stick in an anti-clockwise direction.
- d. Disconnect the OHW connection clamp from the contact wire.

- e. Disconnect the rail clamp or cable connection.
- f. Inspect the equipment for damage as the clamps and lead may have been carrying traction return currents.
- g. Inspect the rail and report any damage or discharge mark to the track discipline representative.

9.13 Temporary rail connections

This section describes the rail connection method for situations where provision shall be made for traction return current to flow via rail connected OHW. Temporary rail connections should be shown on operating diagrams.

9.13.1 Arrangement of temporary rail connections

Temporary rail connections are those connections that are made via an appropriate bolted clamp arrangement to the catenary and a corresponding bolted connection, i.e. not a Pfisterer rail clamp, to either:

- a. The neutral point of an impedance bond.
- b. The trackside negative bus rail at a substation or section hut.
- c. Directly to the Traction Rail in a single Traction Rail return area.

For details of the engineering requirements for Temporary Rail Connections, refer to Transport for NSW (TfNSW) standard *EP 95 20 00 06 SI Methods of Rail Connecting 1500 Volt Overhead Wiring*.

9.13.2 Installing and removing temporary rail connections

This type of connection shall be installed and removed by persons who have signed on to an Electrical Permit.

9.13.3 Installing temporary rail connections

In order to allow for the erection of the temporary rail connection, the following steps shall be carried out in sequence:

- a. Portable Rail Connecting Equipment, (refer to Section 9.12), is erected.
- b. A Permit is issued to allow for the erection of temporary rail connections.
- c. Temporary rail connections are then installed immediately adjacent to the portable rail connection equipment (i.e. at the locations listed on the Permit).

The temporary rail connection shall be secured to the OHW structure, or other suitable structure, clear of the track to permit the clear passage of diesel hauled trains and work trains.

When using the direct rail connection to a single traction rail, the rail connection shall be either to a tapered bolt connection (refer to note 1 of Drawing EL 0011876) or to a welded stud. Only one cable may be terminated to each tapered bolt or stud. The cable shall be connected to the outside of the rail web. Under no circumstances may any form of rail clamp be used.

When connecting to the neutral point of an impedance bond, prior confirmation shall be received from the Signals Engineer that the particular impedance bond(s) to be used are suitably rated to provide an adequate rail connection.

If it is necessary to pass the cable under one rail to connect to the neutral point of the impedance bond, the cable shall be double insulated at the point where it passes under the rail.

- d. The portable rail connection equipment is removed.
- e. The Permit issued for installing temporary rail connections can then be cancelled.

9.13.4 Removing temporary rail connections

To remove a temporary rail connection the following steps shall be carried out in sequence:

- a. Portable Rail Connecting Equipment is erected immediately adjacent to the temporary rail connections.
- b. A Permit is issued to allow for the removal of temporary rail connections.
- c. Temporary rail connections are then removed.
- d. The portable rail connection equipment is removed.
- e. The Permit issued for removal of the temporary rail connections can then be cancelled.

9.14 Equipment subject to fault currents

Portable rail connection equipment clamps and associated connecting cables shall be inspected for effective operation after use, due to the possibility of damage from fault or traction return current.

Rail connecting links or switches and associated connecting cables shall be inspected for effective operation after being subjected to fault currents.

Defective components shall be replaced.

10 Approved equipment

Authorised Persons shall use approved equipment described in SP D 79039. This includes:

- a. 1500 Volt test equipment for testing live/dead,
- b. Portable rail connections, and
- c. Insulated (operating) sticks.

11 Referenced documents

EL D 81020 EDWARD KELLER/ART 1500VDC – 3000A Isolator Equipment Operation
EL E 81064 Remote Isolation and Rail Connecting (RIRC) Switch (Infracore)
EP 95 20 00 06 SI Methods of Rail Connecting 1500 Volt Overhead Wiring
NGE 204 Network Operations
NPR 721 Spoken and written communication
PR D 78102 Electrical Hazards and Warnings
PR D 78104 Securing Systems for Electrical Equipment
PR D 78301 Removal and Restoration of 1500 Volt Supply
PR D 78306 1500 Volt DC Overhead Wiring Structure to Rail Voltage Test
PR D 78700 Working around Electrical Equipment
PR D 78702 Stringing of 1500 Volt OHW Conductors in the Vicinity of Existing Electrical Equipment
SP D 79039 Electrical Tools and Test Equipment
SP D 79049 Safe Approach Distances (SADs)