

Engineering Advice Electrical Distribution Unit	EA D 19-04
Approved by: Nadine Youssef, Associate Director Electrical Distribution Unit, Sydney Trains	Date in Force: 2 May 2019 Date Expires: 18 October 2019
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This Engineering Advice is produced for information and guidance. Adherence to the information in this Advice is recommended but not mandatory.	
<b>Working On and Around Earthing Systems</b>	
Audience: <ul style="list-style-type: none"> <li>• Network Maintenance Division</li> <li>• Engineering System Integrity</li> <li>• Major Works Division</li> <li>• TfNSW</li> </ul>	Main Points: <ul style="list-style-type: none"> <li>• Earth connections shall not be broken when there is a potential of creating a voltage difference across the break</li> </ul>
<b>Reference Document: PR D 78102 Electrical Hazards and Warnings</b>	

## Scope

This Engineering Advice serves the purpose of raising awareness of the hazards of working on and around earthing conductors.

## Background

Recent works required relocation of the earth grid conductors at an inner city substation. During electrical testing a significant level of current was detected in the conductors. Breaking earth conductors without suitable bridging may create dangerous voltages appearing across the break due to leakage currents and voltage rise in the substation earth grid under fault conditions.

## Action required

Per PR D 78102

1. When it is necessary to break a part of any earthing system and there is no parallel connection, bridges of equivalent current carrying capacity shall be connected across the part of the earthing system before it is broken, unless all associated equipment has been isolated.
2. When working on the neutral, negative or earth circuits, using a voltage tester is not sufficient to establish safe conditions. It is necessary to make sure that no current is flowing as breaking a neutral, negative, or earth connection that is carrying current will result in line voltage appearing across the break.  
If a tong tester is available, this could be used to prove that no current is flowing, remembering that on dc equipment a dc tong meter would be needed.

## Contact

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Engineering Procedure  
Electrical Distribution Unit

PR D 78102

## Electrical Hazards and Warnings

Version 1.2

Date in Force: 19 February 2019

# Procedure

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## Document control

Version	Date	Author/ Prin. Eng.	Summary of change
1.0	29 July 2015	Wayne Halls	First issue as a Sydney Trains document, rebranded from previous RailCorp SMS-06-EN-0553 V1.3
1.1	10 July 2018	Chris Leung	3 Yearly Review
1.2	19 February 2019	Nick Loveday	Updated PR D 78102 "Approved by" to Associate Director Electrical Distribution Unit

## Summary of changes from previous version

Summary of change	Section

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## 1. Purpose and scope

To provide general warnings applicable to electrical work on, near or in the vicinity of electrical equipment and to describe a number of more common electrical hazards which may be encountered by Sydney Trains personnel, contractors and the public.

Persons undertaking work where these hazards are present shall ensure the highest practicable level of risk control is applied.

This procedure should be read in conjunction with, and in addition to, the procedure **PR D 78700 Working around Electrical Equipment**, particularly sections 4 and 6.



### NOTE

PR D 78700 Working around Electrical Equipment provides guidance on the risk assessment and planning process.

Not addressed in this procedure are other hazards and risks that are present when working in the rail corridor, in substations, the outdoors or other environments.

## 2. 'Danger Do Not Operate' tags (DANGER Tags)

'Danger Do Not Operate' tags (DANGER Tags) serve as a warning that the electrical equipment to which they are attached shall **not** be operated. DANGER Tags are placed for the safety of persons. See procedure **PR D 78105 DANGER Tags for Electrical Equipment** on the correct procedure for using DANGER Tags on electrical equipment.



### Warning

DANGER Tags shall not be interfered with or removed without the proper authority.

## 3. Warning signs and protective measures

Appropriate permanent or temporary work area markers, safety fences, demarcation taping, warning signs, barriers, guards, plates, warning lights and other protective devices, shall be used as required where hazards exist to employees, contractors or the public.



### NOTE

Particular requirements for demarcation taping of Electrically Safe Work Areas within substations are contained within procedure PR D 78502 Substation Access Permit.

## 4. Electric arcs, Electric shocks and Explosion

### 4.1. Electric Arcs

Serious injury can result from burns caused by electric arcs. Arcs can be caused by attempting to apply, though inadvertently in most cases, an earth or rail connection to live equipment, or by opening non-load breaking 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. Severe burns to the body due to radiated heat and contact with molten materials, and flash injuries to the eyes may result.

Burns may initially appear minor despite significant deep tissue injury. Burns are most often severe at the source (usually hands or head) and ground contact point (usually feet). The severity and extent of tissue damage are influenced by the strength and duration of contact with the source.

Burns from high voltage may appear minor at the surface whilst causing significant damage to underlying deeper tissue. Skin with high resistance will transmit energy to deeper tissues with lower resistance.

Severe tissue burns can result in kidney failure. Low voltage burns look like ordinary thermal burns.

### 4.2. Electric shocks and the human body

The human body is a conductor of electricity, and severe injury or death results if a conducting path that allows electric current to pass through the body is formed. Further details are contained within the procedure **PR D 78700 Working around Electrical Equipment** section 4.2.

In the event that a person receives an electric shock, it is essential that appropriate first aid is provided without delay. Even if there are no immediate signs of injury the requirements of D2013/80869 Electric Shock Protocol shall be complied with.

### 4.3. Explosion

The electrical energy available through a fault on an electrical power system, particularly an underground cable system, can be substantial. In Sydney Trains, DCCBs are designed to withstand a short-duration prospective fault current of 75 kA. (Refer to engineering standard T HR 90003 ST Heavy Rail Traction System – Current Ratings of 1500V DC Equipment. This represents an enormous amount of energy, particularly if the fault is not cleared within a very short time duration.

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

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

## 4.4. Mitigation Measures against Electric Arcs, Electric Shocks and Explosions

Mitigation measures against the occurrence of electric arcs and explosions include, but not limited to, the following:

- Never operate off-load isolating switches on load.
- Follow the correct procedure when undertaking operating work, (eg prove dead at every location immediately prior to the application of earths or rail connections).
- Wear the appropriate PPE when undertaking switching operations, live work, or other work within substations. (Refer to procedure PR D 78101 General Requirements for Electrical Work.)
- Work under Electrical Permit conditions unless not practicable to do so. (Refer to procedure PR D 78700 Working around Electrical Equipment section 8.)
- Where live work is to be carried out, appropriately Authorised Persons undertaking such work, as described in procedure PR D 78701 Personnel Certifications – Electrical, shall strictly adhere to the appropriate Safe Work Method Statements, including the correct use of insulated tools.
- Work is assessed, planned, managed, supervised and conducted in accordance with the:
  - procedure PR D 78700 Working around Electrical Equipment,
  - procedure PR D 78000 Electrical Network Safety Rules, and
  - all documents referenced by the preceding two documents.

## 5. Earthing system

### 5.1. Disconnected or broken earth connections

Earth connections between equipment and the earthing system shall not be removed while the equipment is in service unless a suitable alternative earth connection is provided first.



#### **Warning**

If an earth or neutral connection is broken or removed from equipment that is in service, a dangerous voltage may appear on the neutral or earth cable connected to that equipment.

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Equipment that can produce dangerous voltages under these conditions includes voltage transformers and surge arresters.

### 5.2. Substation earth grid voltages and transferred earth potentials

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

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

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



### 5.3. 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, bridges of equivalent current carrying capacity shall be connected across the part of the earthing system before it is broken, unless all associated equipment has been isolated.



#### Warning

Particular care shall be taken when reconnecting a broken earth lead.

### 5.4. Check to ensure No missing earthing connections Before Touching

Incidents of copper theft and other vandalism acts create safety hazards.

To avoid possible electric shock, it is essential that all people gaining access to or working inside substations shall check to ensure that there are no missing earthing connections at substation access gates, fencing and switch operating handles etc. prior to touching such items or undertaking switching operations.

The photographs below show where earthing conductors have been stolen from a substation structure and a switch down rod.





## 6. Neutral, negative and earth circuits

When working on the neutral, negative or earth circuits, using a voltage tester is not sufficient to establish safe conditions. It is necessary to make sure that no current is flowing as breaking a neutral, negative, or earth connection that is carrying current will result in line voltage appearing across the break.

If a tong tester is available, this could be used to prove that no current is flowing, remembering that on dc equipment a dc tong meter would be needed.

Also note that in the case of the negative for a harmonic filter, while it is in the dc negative circuit, the current through the harmonic filter is audio frequency ac, not dc or mains frequency ac, and care shall be taken to make sure an appropriate instrument is used.

When working on the neutral or negative circuits, other precautions include:

- Checking that the number of connections is what is expected - additional unexpected connections could indicate trouble and shall be investigated before work proceeds.
- Checking any labels on all conductors connected to a bar or link, not just labels on the conductors being worked on.

## 7. Rectifier negative

While the rectifier negative circuit is normally near to rail potential, in the event of a fault causing a DCCB opening, high voltages can appear across the reactor and therefore between the rectifier negative and rail.



### Warning

Closing the rail earth contactor (REC) does not reduce the risk of shock from the rectifier negative.

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Refer to procedure PR D 78304 Work on 1500 Volt Negative Equipment Inside Substations for more details.

## 8. Capacitors

Capacitors store electrical energy and care shall be taken when working on equipment with capacitors. Large capacitors or banks of capacitors shall be:

- isolated, and then
- discharged through an appropriately rated load or allowed to naturally discharge over an appropriate time frame, and
- then proved dead prior to commencement of work.



### Warning

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

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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 shall be treated in the same manner.

## 9. Battery rooms

On routine inspection and maintenance work, where large quantities of electrolyte are not handled, a face shield or goggles shall be worn. In addition when the electrolyte is in liquid form, a dust coat should also be worn. These personal protective equipment (PPE) requirements are in addition to clothing, footwear and other PPE as per procedure **PR D 78101 General Requirements for Electrical Work**.

Unprotected hands and clothing shall be kept away from battery cells at all times.

Work performed on a battery in service shall use methods which preclude circuit interruption or arcing in the vicinity of the battery.

The handles of all tools shall be insulated and step ladders shall be non-metallic. Test equipment leads shall be firmly connected with sufficient length of cable to prevent accidental arcing in the vicinity of the battery. All connections to load test equipment shall include short-circuit protection.

Smoking, the operation of electric hand tools, the use of open flame and the operation of equipment that produces electric arcs is prohibited in the immediate vicinity of the battery.

Any spilled electrolyte shall be diluted or neutralised immediately and removed.

If electrolyte splashes in the eye or on the skin, the aim of the treatment is to dilute and eliminate the acid or alkali by flooding the eye or skin immediately with water. Following irrigation of the eye or skin, immediate medical attention shall be sought.

## 10. Current transformers

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

## 11. Work on or above and roof equipment of electric vehicles

### 11.1. Work on or above electric vehicles

An Electrical Permit to Work (refer **PR D 78501**) shall not be issued for work on or above the roof of an electric locomotive or electric vehicle (irrespective of the vehicle being a 4 car or 8 car set) if there is live overhead wiring above the vehicle or any pantograph, regardless of that pantograph being lowered and/or isolated.

## 11.2. Securing of damaged pantographs

Care shall be taken when it is necessary to secure or make safe a damaged pantograph of an electric locomotive or other type of vehicle, including but not limited to the Tangara, Millennium, Oscar or Waratah. Due to the vehicle design, even if one pantograph is lowered from the overhead wiring, it may still be alive as it may be electrically connected to the other pantograph which is raised and in contact with the overhead wiring.

Accordingly if the vehicle is:

- an electric locomotive, both pantographs shall be lowered and the associated air supply that controls the pantograph raising and lowering is isolated, or
- an electric multiple unit (EMU) motor car or trailer, the associated pantograph shall be lowered and the associated air supply that controls the pantograph raising and lowering is isolated, or
- a Tangara, Millennium or Outer Suburban car, both pantographs on the 4 car set shall be lowered and the associated air supply that controls the pantographs raising and lowering is isolated, or
- a Waratah car, all pantographs on the 4 car set shall be lowered, the associated air supply that controls the pantographs raising and lowering is isolated, and the High Voltage Earth Switch (Refer Appendix A) is operated by manually rotating the handle from the “Normal” to the “Earth” position, special locked and DANGER tagged (Refer Section 2),

before testing dead and then commencing work to secure or make safe the damaged pantograph.

If a damaged pantograph is tied down and it is within **50mm** of the roof, the pantograph isolating switch shall be opened and all other electrically connected pantographs shall be lowered and the associated air supplies isolated.

## 11.3. Roof mounted capacitors

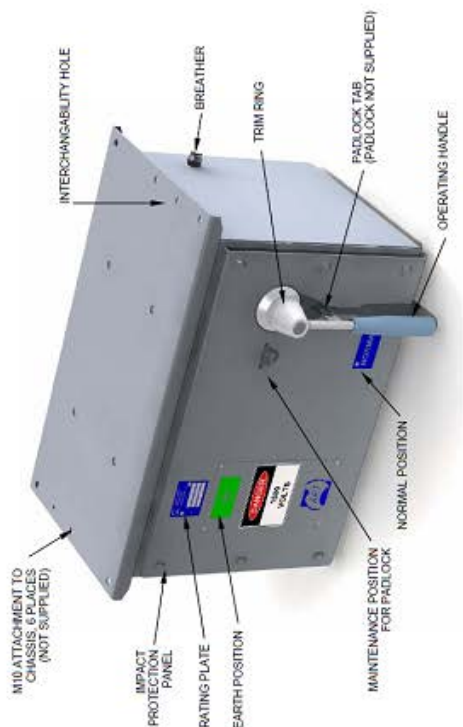
Roof-mounted capacitors of electric vehicles shall be treated as being live unless isolated, discharged and proven dead - refer to the “Warning” of Clause 8 above.

## 12. References

<b>AS 2676.1-1992</b>	Guide to the installation, maintenance, testing and replacement of secondary batteries in building. Part 1: Vented cells
<b>AS 2676.2-1992</b>	Guide to the installation, maintenance, testing and replacement of secondary batteries in building. Part 2: Sealed cells
<b>T HR 90003ST</b>	Heavy Rail Traction System – Current Ratings of 1500 V dc Equipment
<b>PR D 78000</b>	Electrical Network Safety Rules
<b>PR D 78101</b>	General Requirements for Electrical Work
<b>PR D 78304</b>	Work on 1500 Volt Negative Equipment Inside Substations
<b>PR D 78502</b>	Substation Access Permit
<b>PR D 78501</b>	Electrical Permit to Work
<b>PR D 78105</b>	DANGER Tags for Electrical Equipment
<b>PR D 78700</b>	Working around Electrical Equipment
<b>PR D 78701</b>	Personnel Certifications – Electrical Authorisations

Location of the High Voltage Earth Switch (HVES) on the Waratah

# High Voltage Earth Switch (HVES)



- The HVES units are located at the Number One ends of the Trailer Driver Cars and Trailer Cars.
- The HVES is operated by manually rotating the handle 90° from the “Normal” to the “Earth” position.

