NEW SOUTH WALES FIRE BRIGADES

Electrical Hazard Awareness Manual

VERSION 02 APPROVED: SEPTEMBER 2009

© Copyright State Government of NSW (NSWFB) 2009
All rights reserved. The information contained in this manual is provided for the use of approved personnel in the performance of their duties. Apart from any use as permitted under the Copyright Act 1968, no part of this manual may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage and retrieval system, without permission in writing from the New South Wales Fire Brigades (NSWFB).
Published by:
NSWFB Lessons Learned Centre
Level 10, 227 Elizabeth Street,
Sydney NSW 2000
Telephone: (02) 9265 2614
Facsimile: (02) 9265 2886

Document Control

Version 02, September 2009

Acknowledgements:

NSWFB gratefully acknowledges the contribution of EnergyAustralia's Operating Standards and Accreditation Unit, Network Control who gave permission for their training guide *Electrical Hazard Awareness for Emergency Services Personnel* to be used as a basis for this document.

CD electronic master files located with:

Manager Operational Information, Lessons Learned Centre

Signed hardcopy and working file located with:

Manager Operational Information, Lessons Learned Centre, **NFB/05204**

Produced by NSWFB Lessons Learned Centre

Has this document been printed or copied?

Check you have the most recent version by comparing the date and version control on the footer or on this indicia page with the version that can be found on the station portal on the NSW Fire Brigade intranet. Consider the online document the master.

This document is intended for release as an electronic PDF document for online viewing.

Contents

1 Introduction 1

1.1 References 1

1.2 Bibliography—other relevant publications 1

1.3 Purpose 1

1.4 Scope 2

1.5 Terms and abbreviations 2

2 Electricity basics 7

2.1 Basic electrical facts 7

2.1.1 Electricity terminology 7
2.1.2 High voltage and low voltage 7
2.1.3 Nature of electricity 8
2.1.4 Effect of electricity on the body 8
2.1.5 High voltage electric shock 10

3 Electrical network infrastructure 12

3.1 Electricity supply systems 12

3.2 Power stations 13

3.3 Transmission towers 13

3.4 Sub-transmission poles 14

3.5 Bulk supply points 14

3.5.1 Construction 15
3.5.2 Security 15
3.5.3 Risks 15

3.6 Zone substations 15

3.6.1 Construction 16
3.6.2 Security 16
3.6.3 Risks 16

3.7 Chamber/ground/enclosed substations 17

3.7.1 Construction 17
3.7.2 Security 18
3.7.3 Risks 18

3.8 Kiosk 18

3.8.1 Construction 19
3.8.2 Security 19
3.8.3 Risks 19

3.9 Pole substations 20

3.9.1 Construction 20
3.9.2 Security 21
3.9.3 Risks 21

3.10 Pillar Box 21

3.10.1 Construction 22
3.10.2 Security 22
3.10.3 Risks 22

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.11 Insulators and conductors....22
3.11.1 Insulators....22
3.11.2 Conductors....22
3.11.3 Distribution insulators and conductors....23
3.11.4 Underground overhead connection....27
3.11.5 Dangers of conductive materials....28
3.12 Protection systems and reclose feature....29
3.12.1 Introduction....29
3.12.2 Zone substation recloser....29
3.12.3 Pole top recloser....29
4 Electrical hazards....31
4.1 Definitions....31
4.2 Risk assessment....31
4.3 General hazards....32
4.3.1 Risks....32
4.3.2 Control measures....32
4.4 Personal protective equipment....33
4.4.1 Electrical safety kit....33
4.4.2 Cleaning and maintaining electrical worker's gloves....34
4.4.3 Modiewark GLM Mini Rescue....35
4.5 Voltage gradients on the ground surface....35
4.5.1 Ground gradient effect....35
4.5.2 Step and touch potential parameters....36
4.5.3 Step potential....36
4.5.4 Touch potential....37
5 Critical incidents....39
5.1 Fire hazards....39
5.1.1 Building fires....40
5.1.2 Isolation procedure for domestic 240/415 volt switch boards....40
5.1.3 Electrical safe working practices....43
5.2 Damaged support structures and wires under tension....45
5.2.1 Risks....46
5.2.2 Control measures....46
5.3 Fallen wires....47
5.3.1 Risks....47
5.3.2 Control measures....47
5.4 People in contact with live wires or equipment....47
5.4.1 Risks....47
5.4.2 Control measures....47
5.5 People trapped in vehicles by fallen wire....47
5.5.1 Risks....47
5.5.2 Control measures....48
5.6 Vehicles in contact with electricity kiosks....48
5.6.1 Risks....48
5.6.2 Control measures....48

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.7 Electrical network incidents 49

5.7.1 Electrical substation fires 49
5.7.2 Fire suppression systems 50
5.7.3 Fires and explosions in underground electrical vaults and tunnels 52
5.7.4 Fire fighting near high voltage powerlines..53
5.7.5 Pole fires..55

5.8 Other incidents involving electricity..56

5.8.1 Trees and branches in contact with wires 56
5.8.2 Unauthorised people in substations or on electrical structures 56
5.8.3 Debris on structures or wires 57
5.8.4 Trains, trams and the Sydney Monorail..57
5.8.5 Hybrid vehicles..58
5.8.6 Uninterruptible power supply (UPS) 62
5.8.7 Backup generators..62
5.8.8 Low clearance to live wires due to sagging wires or floods..........63

Appendix A Resources..64

Index 65

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Table of figures

Figure 1 Electrical burn....10
Figure 2 Effect of electrical current passing through the body....10
Figure 3 Electricity distribution from power station to consumer....12
Figure 4 Power station....13
Figure 5 Typical high voltage transmission towers....13
Figure 6 Sub-transmission pole line....14
Figure 7 Bulk supply point....14
Figure 8 Enclosed zone substation example—City Central....15
Figure 9 Open zone substation example—Homebush Bay....16
Figure 10 Enclosed substation....17
Figure 11 Ground substation....17
Figure 12 Kiosk—External view....18
Figure 13 Kiosk—Internal view of the high voltage end....19
Figure 14 Pole mounted substation....20
Figure 15 SWER pole substation....20
Figure 16 Underground power pillar....21
Figure 17 Typical pole configuration....23
Figure 18 High voltage cables and insulators....24
Figure 19 Post insulators....25
Figure 20 High voltage insulator recognition diagram....25
Figure 21 ABC mains....26
Figure 22 Low voltage aerial bundled cable....26
Figure 23 LV service aerial (single phase)....26
Figure 24 High voltage aerial bundled cable....26
Figure 25 HV covered conductor thick (CCT)....26
Figure 26 ABC mains....27
Figure 27 High and low voltage cables and insulators with an underground connection....27
Figure 28 Pole top recloser....30
Figure 29 Electrical safety kit....33
Figure 30 Electrical workers gloves....34
Figure 31 General purpose gloves worn over the top....34
Figure 32 The Modiewark GLM Mini Rescue Tester....35
Figure 33 Voltage gradient area after a vehicle impact on a power pole....36
Figure 34 Step potential on a high voltage gradient....37
Figure 35 Touch potential....38
Figure 36 Typical domestic underground power service....39
Figure 37 Typical domestic service....39
Figure 38 Standard domestic switchboard (without metal meter box)....41
Figure 39 Standard domestic switchboard (inside metal meter box)....41

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 40 Apartment block distribution board to units 42
Figure 41 Unit switchboard (usually in cupboard in unit) 42
Figure 42 Feeling your way through smoke 44
Figure 43 High voltage transmission cables in an electrical storm 45
Figure 44 Pole damage—storm 46
Figure 45 Wall mounted access box for CO_2 injection 51
Figure 46 Wall box opened 51
Figure 47 Ground level access box for CO_2 injection 51
Figure 48 Access cover opened 51
Figure 49 Fire proximity to high voltage cables 54
Figure 50 Extinguishing a Pole Fire 55
Figure 51 Toyota Prius 59
Figure 52 Honda Insight 59
Figure 53 IGCT relay 60
Figure 54 Yellow HEV fuse 60

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

1 Introduction

1.1 References

Energy Networks Association 2006, *ENA 008 – 2006, National Guidelines on Electrical Safety for Emergency Service Personnel*, Standards Australia, Sydney.

EnergyAustralia 2006, *Electrical Hazard Awareness for Emergency Services Personnel,* Version 1.4, EnergyAustralia, Sydney.

Fire Brigades Act 1989 (NSW).

Fire Brigades Regulation 2003 (NSW).

McKie, P 2007, *Active First Aid*, 7th edn, Active Publications Pty Ltd, Fyshwick, ACT.

NSW Fire Brigades 2005, *Recommended Practice: Automatic External Defibrillator: Zoll AED Plus*, NSWFB, Sydney.

NSW Fire Brigades 2007, *Recommended Practice: Modiewark GLM Mini Rescue non-contact voltage detector*, NSWFB, Sydney.

Occupational Health and Safety Act 2000 (NSW).

Occupational Health and Safety Regulation 2001 (NSW).

For a list of NSW Fire Brigade documents, see Appendix A: Resources.

1.2 Bibliography—other relevant publications

Energy Networks Association 2006, *ENA NENS 01 – 2006, National electricity network safety code*, Standards Australia, Sydney.

Energy Networks Association 2006, *ENA NENS 04 – 2006, National guidelines for safe approach distances to electrical and mechanical apparatus*, Standards Australia, Sydney.

Standards Australia 2002, *AS/NZS 60479.1:2002, Effects of current on human beings and livestock, Part 1: General aspects*, Standards Australia, Sydney.

Standards Australia 2002, *AS/NZS 60479.2:2002, Effects of current on human beings and livestock, Part 2: Special aspects*, Standards Australia, Sydney.

1.3 Purpose

This manual is designed to:

- Instruct NSWFB personnel in the essential aspects of Incident Management for some likely hazardous electrical incidents
- Emphasise safety and hazard awareness aspects of dealing with electrical incidents
- Prevent exposing NSWFB personnel to undue risk from electrical hazards.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

1.4 Scope

The material covered in this manual:

- Applies to the electrical hazards associated with the electrical apparatus provided for the transmission and distribution of electricity
- Does not supersede the requirements of any act, regulation, code or standard applicable to any state, territory or federal jurisdiction.

1.5 Terms and abbreviations

This is a list of common terms and abbreviations used by electricity suppliers.

Item	Description
AC	Alternating current.
Alive or live	Alive or live means that mains and apparatus are: • connected to an electricity supply source • in danger of becoming energised because of hazardous induced or capacitive voltages.
AOp	Area operator.
Authorised person	An authorised person is a trained and competent person who is approved to carry out specific duties to do with the supply and use of electricity. Authorised person includes accredited service providers and their employees.
Bulk supply point	A bulk supply point supplies power to the distribution network and can be a: • Power station • Substation • Switching station • Connection to a high voltage feeder.
CCA	Copper chrome arsenate. A chemical treatment for wood which tints the wood green. Poles treated with CCE give off toxic gases when alight or smouldering.
Conductor	A wire, cable, object or form of metal capable of carrying an electric current.
DC	Direct current.
De-energised	De-energised mains and apparatus are not connected to an electricity supply. However they are not necessarily isolated.
Earth/earthed/ earthing	The terms earth/earthed/earthing refer to mains and apparatus electrically connected to the earth. The electrical system is connected to earth for safety and high voltage equipment is earthed before it is touched. Sometimes known as ground.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Item	Description
Electrical station	An electrical station is any enclosed substation or switching station of the indoor, outdoor (including pole transformers) or underground type.
Electrocution	Death by electric shock.
Exposed	Exposed means that a conductor is not effectively guarded or protected by one or more of the following: • A fixed barrier of suitable material in sound condition • Insulation adequate for the voltage • An earthed metal barrier • An earthed metallic or non-metallic screen • Low voltage terminal shrouding that complies with relevant standards.
Extra low voltage	Extra low voltage is normally not more than 50 volts AC or 120 volts ripple free DC.
Generating station	Any building or enclosure where electricity can be generated.
High voltage	High voltage is normally more than 1000 volts AC or 1500 volts DC.
HMRU	Hazardous Materials Response Unit, sometimes known as Hazmat.
HV	High voltage.
IC	Incident controller.
Isolate/isolated	Mains and apparatus are isolated if they are disconnected from all possible sources of electrical energy by: • opening switches • withdrawing circuit breakers • removing fuses, links or connections • tying back bonds and precautions such as locking and danger tagging have been taken to prevent the unauthorised or unintentional closure of the above items. Some of these tasks are normally only performed by authorised personnel.
Kiosk	Power substation located on the street in a locked metal/fibreglass box, the size of which can be anything from about 1 m x 1.5 m to 1.8 m x 3 m, usually green in colour.
Low voltage	Normally more than 50 volts AC or 120 volts ripple free DC but not more than 1000 volts AC or 1500 volts DC.
LV	Low voltage.
kV	1000 volts.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Item	Description
Mains and apparatus	Mains and apparatus is any: • Conductor that is normally alive, or is intended to be connected to form part of the network. Mains and apparatus also include conductors that have been disconnected from the network. • Equipment used in supplying electricity. For example: * overhead line * cable * generator * transformer * switchgear * fuses and links. • Other equipment which supplies or uses high voltage. For example: a metering unit, cranes and motors. Mains and apparatus include all parts of the equipment, e.g. conductors, insulation, earthed metalwork and cable sheaths.
Meter box	Metal box used to house switch board in house installation.
Minimum safe working distances	Minimum safe working distances are distances that must be maintained by people and their tools and equipment when they are near exposed live conductors. For emergency services personnel, this distance is 8 m. Qualified and authorised electricity authority personnel can and, are required to, work safely significantly closer to the electrical hazard to make the area safe.
Near	Closer to a live exposed conductor than the minimum safe working distance.
Network	The network is all the mains and apparatus used to supply electricity. The network ends at the consumer's terminals. The terms used to describe the parts of the network are: 1. Transmission and sub-transmission network: All mains and apparatus energised at nominal voltages of 33 000 volts and above. 2. High voltage distribution network: All mains and apparatus energised at a nominal voltage above 1000 volts but less than 33 000 volts. 3. Low voltage distribution network: All mains and apparatus energised at a nominal voltage above 50 volts, up to and including 1000 volts.
OH	Overhead.
Operator	An operator is a person who is authorised to carry out electrical operating work.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Item	Description
Overhead	An aerial conductor and its associated mains and apparatus erected outdoors for supplying electricity. It does not include: • any pole or similar support • conductors within the boundary of an electrical station.
POA	Point of attachment
PPE	Personal protective equipment
PVC	Polyvinyl chloride
SCBA	Self contained breathing apparatus
Shock	Trauma caused by the passage of electric current through the body (as from contact with high voltage lines or being struck by lightning); usually involves burns and abnormal heart rhythm and unconsciousness.
SWER	Single wire earth return.
Switch board	A board which carries meters, fuses and circuit breakers.
UG	Underground.
UGOH	Underground cable to overhead conductor connection.
Underground	Underground electrical cables and apparatus. Includes high and low voltage power distribution.
Uninterruptible Power Supply (UPS)	A device which maintains a continuous supply of electric power when utility power is unavailable.
Voltage	The pressure to drive the electricity around a circuit.
XLPE	Cross linked polyethylene

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

The terminology below is employed when talking about the telecommunication system within the electricity network.

Item	Description
Optus Communications	Optus Communications uses fibre optic cable, laid between major cities and in rings around Australia's capital cities, for long distance communications and business network services. The cable is usually identified by marker posts.
Optus Vision or Telstra	Optus Vision/Telstra operates a telecommunications and cable TV network, using cables located on utility poles and in underground ducts or rights-of-way. The network consists of several components that could be damaged and require immediate action by Optus/Telstra authorised personnel.
Amplifier	A rectangular aluminium box attached to the strand at some utility poles used to amplify signals carried on the coaxial cable. The cables are attached at both ends of the amplifier.
Coaxial cable	Black or grey PVC jacketed aluminium cable used to carry telecommunications and video signals over short distances. Usually lashed to the strand with small wires.
Fibre optic cable	A round black or grey PVC jacketed cable with multiple strands of thin glass fibres through the centre of the cable. Used for telecommunications and video signal transportation over long distances.
Lead-in cable	A black cable constructed of a coaxial cable, a cable with twisted pairs to power telephony and a small steel bearer wire all individually sheathed in a PVC jacket and joined by a web, used to transport telecommunications and video signals into the customer's home.
Power supply	A square housing attached to a utility pole that converts the power company's 240 V AC to 90 V AC. The housing also contains batteries for back up power in the case of interruption of the electricity supply. The 90 V is supplied through the coaxial cable to power amplifiers in the network.
Strand	A stranded steel cable used to support broadband cables and apparatus. The strand is connected to the electricity supply utility's multiple earthed neutral.
Tap	A small rectangular aluminium housing attached to the strand at some utility poles. Coaxial cable is attached at each end of the tap with a lead-in cable attached at the base. They are used to split telecommunications and video signals to the home.
Telco	A company providing or constructing a communications network on/in existing electrical infrastructure, i.e. on poles or in ducts.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

2 Electricity basics

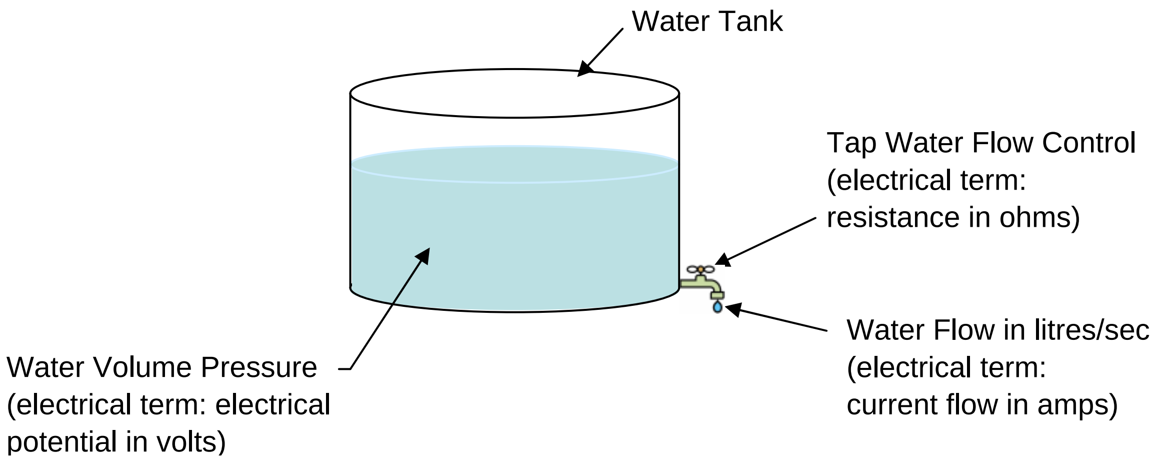
2.1 Basic electrical facts

2.1.1 Electricity terminology

For an electrical circuit to exist there are three basic requirements:

- Voltage
- Current
- Resistance.

Using the water tank analogy these terms can be better explained.



Given the above diagram, for a given amount of water pressure (volts), an amount of water (current) will flow for a given tap control (resistance).

2.1.2 High voltage and low voltage

Transmission and distribution voltages are defined either high or low.

High voltage

Voltages **above** 1000 volts AC and 1500 volts DC are classified as high voltages (HV).

High voltage installations are always either high off the ground or behind security fencing. Most people recognise the hazards associated with these installations. Typical high voltages are 11 000 volts or greater.

Low voltage

Voltages **below** 1000 volts AC and 1500 volts DC are classified low voltages (LV).

Nearly all industrial equipment and domestic appliances operate at a low voltage, typically, 415 volts AC and 240 volts AC respectively.

It is important to recognise that, statistically, most shocks, injuries and fatalities occur when people are exposed to low voltage.

(The value of available current will vary despite voltage.)

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

2.1.3 Nature of electricity

Mains electricity must have a continuous conducting path for current to flow. Electricity will always find the easiest and quickest path to earth and will use anything or anybody to make the connection if it is close enough to the electrical source. This is true for any electrical current irrespective of voltage.

Electricity, especially at higher voltages, can arc over or jump across an air gap to create a path to earth. Direct contact is not required for a person or object they are holding or in contact with, to become part of the circuit.

Electrical sources can be:

- Home generating plant
- High voltage overhead mains
- Low voltage overhead mains
- Overhead street lighting
- Underground mains
- Solar power panels
- Uninterruptible power supplies (UPS)
- Extra low voltage supplies (which may be transformed up)
- Auxiliary supplies
- Inverter supplies (may be in vehicles)
- Rail traction systems
- Embedded supplies (computer systems)
- Batteries.

2.1.4 Effect of electricity on the body

The danger of an electric shock is from contacting:

- Two live (actives) wires
- A live wire and earth
- A live wire and a neutral
- A neutral and earth
- Any two wires with a difference in potential.

Typical electrical emergencies result from:

- A faulty switch or appliance cord (and/or by non-authorised electrical home repairs)
- Children playing with or coming into contact with a cord or plug
- Contact between an electrical appliance and water
- Fallen aerial conductors following a storm or accident
- Lightning strike.

Each year in Australia, there are several deaths from lightning strikes which occur when a person is the tallest feature in the landscape, such as an open playing field, golf course or boat.

In all cases but lightning strike, there is a risk to the rescuer of electric shock.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

The human body is an efficient conductor of electricity. When a person receives an electric shock, electricity is conducted through the body. Some body parts, such as the skin, resist the electrical current. Resistance produces heat, which can cause burn injuries. A victim may receive significant burns or the electric shock may make the heart beat erratically or even stop. Respiratory arrest may occur. Suspect a possible electrical injury if you hear a sudden loud pop or bang and/or see an unexpected flash. The severity of an electrical burn depends on the type and amount of contact, the current's path through the body, and how long the contact lasted. Electrical burns are often deep, and the victim will have both an entrance and an exit wound. Although these wounds may look superficial, the tissue below may be severely damaged.

The effect of electricity on the body depends on the amount of current and the length of time the body is exposed to the current and permanent internal organ damage can result.

It is the current that injures or kills and the voltage that pushes the current through the body. A small amount of current for a few seconds can be fatal.

In certain circumstances, currents as low as 10 mA can cause death. Average distribution systems can carry up to 400 000 times this amount of current.

Current (milliamperes—mA)	Likely effect on the human body
1	A slight tingling sensation
2 to 9	A small shock
10 to 24	Muscles can contract and cause paralysis. Burns occur at contact point. (Threshold of voluntary action.)
25 to 74	Respiratory muscles can become paralysed. Painful shock with entry/exit burns.
75 to 300	Ventricular fibrillation. Shock usually fatal. Distinct entry/exit burns.
>300	Death is almost certain. Severe burns to skin, limbs and internal organs. (Survivors' burnt limbs often need amputation.)

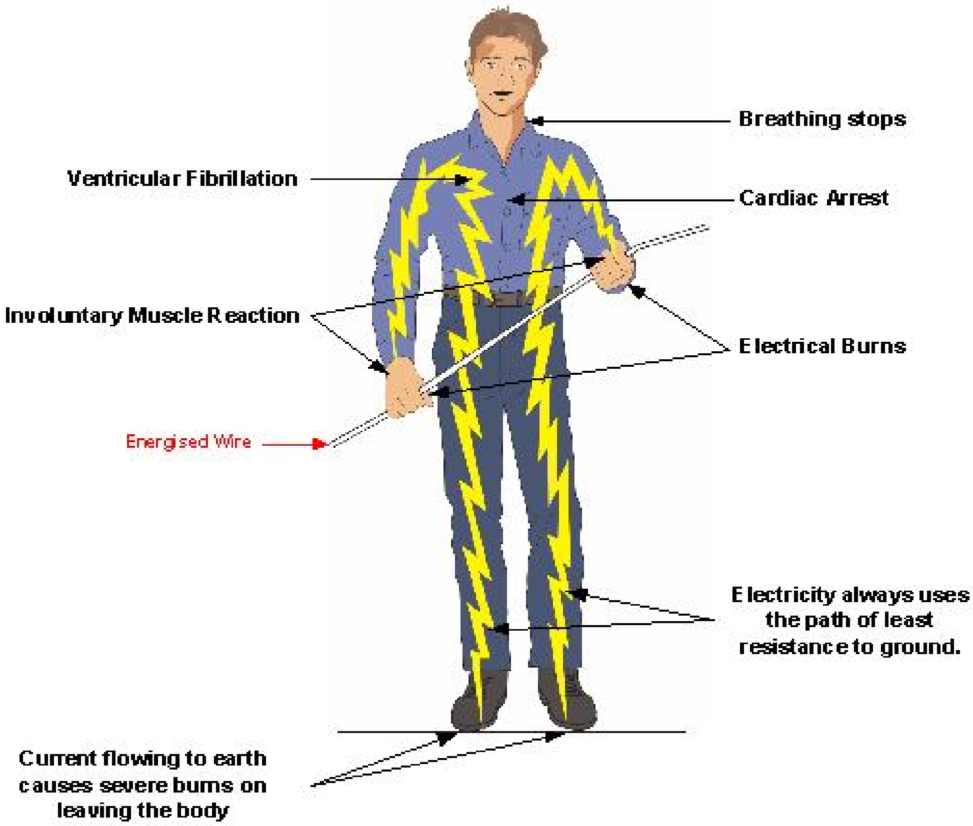
Emergency first aid

Follow the Emergency Action Plan: Danger (safety), Response, Airway, Breathing, Compressions, Defibrillation (DRABCD). Refer to *Active First Aid* (McKie 2006), issued by the NSWFB, and *Recommended Practice: Automated External Debrillator: Zoll AED Plus*.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 1 Electrical burn

Figure 2 Effect of electrical current passing through the body



2.1.5 High voltage electric shock

Contact with high voltage often results in the person being blasted away amid a large powerful arc or explosion. This may result in less internal organ damage; however, the person usually suffers severe surface burns.

A person in close proximity to a large electrical arc can suffer:

- Severe burns from the intense heat
- Internal injuries caused by gas and heat

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Serious eye damage caused by ultraviolet rays
- Physical injuries resulting from being thrown by the **blasting** action of a HV source, e.g. fractures and fall related injuries
- Loss of limbs.

High voltage shock involves an extreme degree of danger to rescuers due to the capacity of the electricity to earth itself by arcing across an air gap to an object or person. This risk increases with humidity and high voltage conductors have danger zones around them of up to 8 metres depending on the voltage they carry. If the electrical source is part of the electrical distribution grid (poles, pylons, underground cables, transformers or stations) you must not enter the area until electrical authorities have certified it safe. You can do nothing for a casualty within the zone of danger! Protect yourself and others.

Ensure that bystanders do not approach the scene and remain at least 8 metres away from the nearest suspected energised material.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3 Electrical network infrastructure

3.1 Electricity supply systems

In New South Wales, electricity is generated by Macquarie Generation, Delta Electricity and Eraring Energy and sold at sub-transmission switching stations to various electricity distributors.

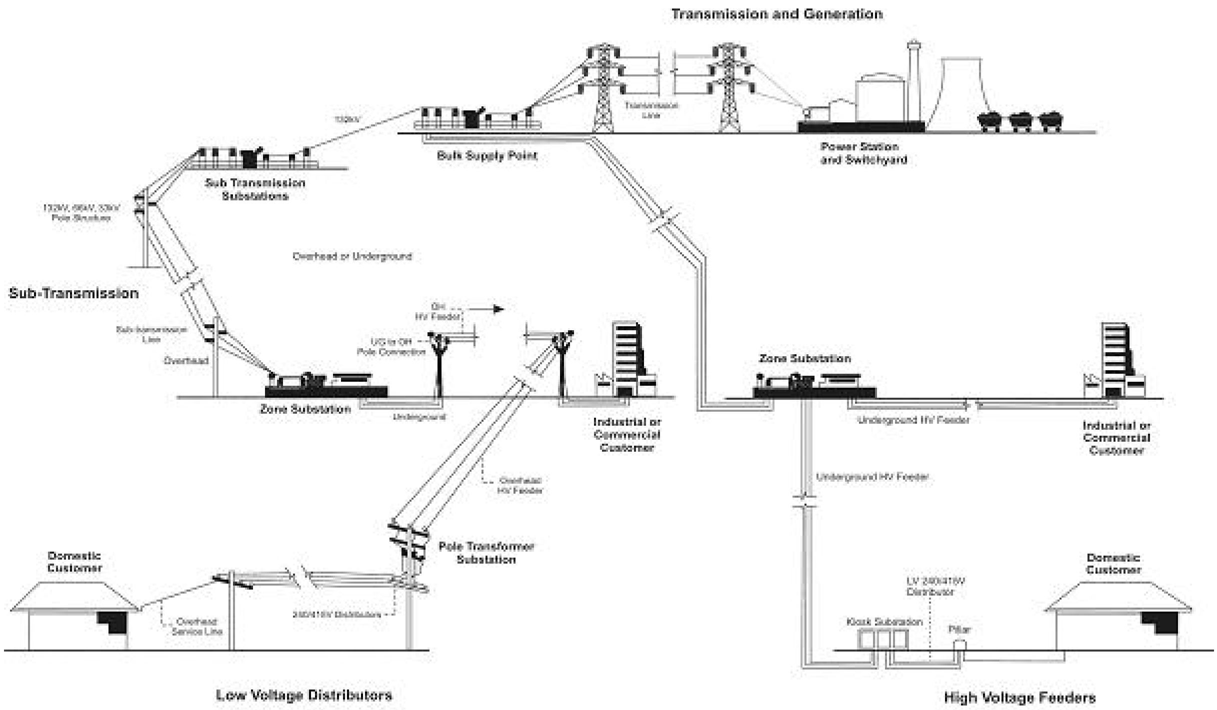
These electricity distributors purchase electricity at 132 kV, 66 kV and 33 kV. It is then transmitted to zone substations by underground or overhead sub-transmission feeders.

At zone substations, electricity is transformed from sub-transmission voltages to 11 kV. It is then transmitted by overhead or underground feeders to distribution centres. When these feeders are overhead, the distribution centres are usually pole transformer type substations. However, if the feeders are underground, then the distribution centres can be kiosks, outdoor enclosure substations, indoor substations, underground substations, or even pole transformer substations. Normally the larger the substation the higher the voltage and in some cases transformers are mounted on poles or in small enclosures (kiosks) in suburban streets.

At distribution centres, the electricity is transformed from 11 kV to the standard 415/240 volt, 3-phase, 4-wire supply for domestic and commercial use or 600 volt – 1500 volt DC for electric traction.

To minimise the loss of supply to customers in case of a breakdown of part of the supply system, each zone is kept separate. The 11 kV feeders are usually operated as radials and the supply from each distribution centre is separated from adjacent distribution centres.

Figure 3 Electricity distribution from power station to consumer



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.2 Power stations

Power stations are the generating source of the electricity. A catastrophe here has the potential to black out large areas.

Figure 4 Power station

The above photograph shows the Eraring coal fired power station.

3.3 Transmission towers

Transmission towers carry power from power stations to bulk supply points in voltages of:

- 500 000 or 500 kV
- 330 000 or 330 kV
- 132 000 or 132 kV.

Figure 5 Typical high voltage transmission towers

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.4 Sub-transmission poles

Sub-transmission towers and pole lines carry power from bulk supply points to major substations in voltages of:

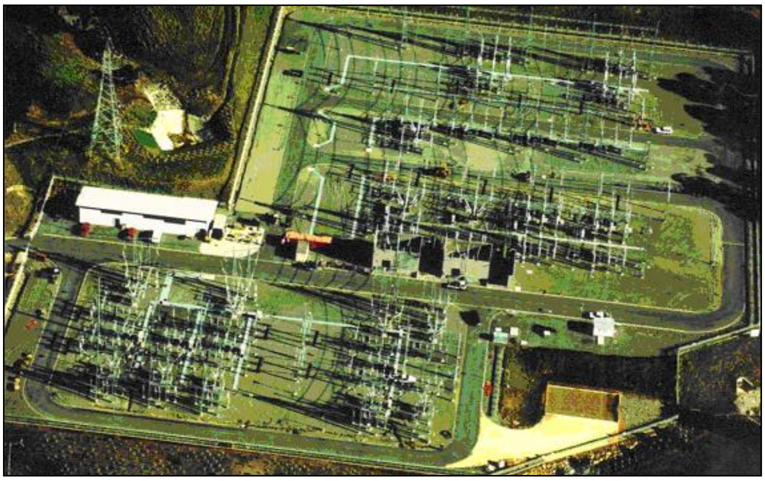
- 132 000 or 132 kV
- 66 000 or 66 kV
- 33 000 or 33 kV.

Figure 6 Sub-transmission pole line

3.5 Bulk supply points

Bulk supply points are the entry points of electricity from the generator to supply the distribution network.

Figure 7 Bulk supply point



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.5.1 Construction

Bulk supply points are large switchyards containing transformers, switch gear and ancillary equipment required to feed the distribution system. Transgrid is the owner/operator of bulk supply points. Currently, there are 82 in NSW.

3.5.2 Security

Bulk supply points are fenced and have controlled entry and exits. Unauthorised persons entering bulk supply points run the risk of serious injury/death from HV shock.

3.5.3 Risks

Electrical

High voltages and low voltages from incoming and outgoing supplies.

Shrapnel from exploding electrical apparatus under fault conditions.

Fire

Oil within the main transformer tanks and fins, and PVC cabling.

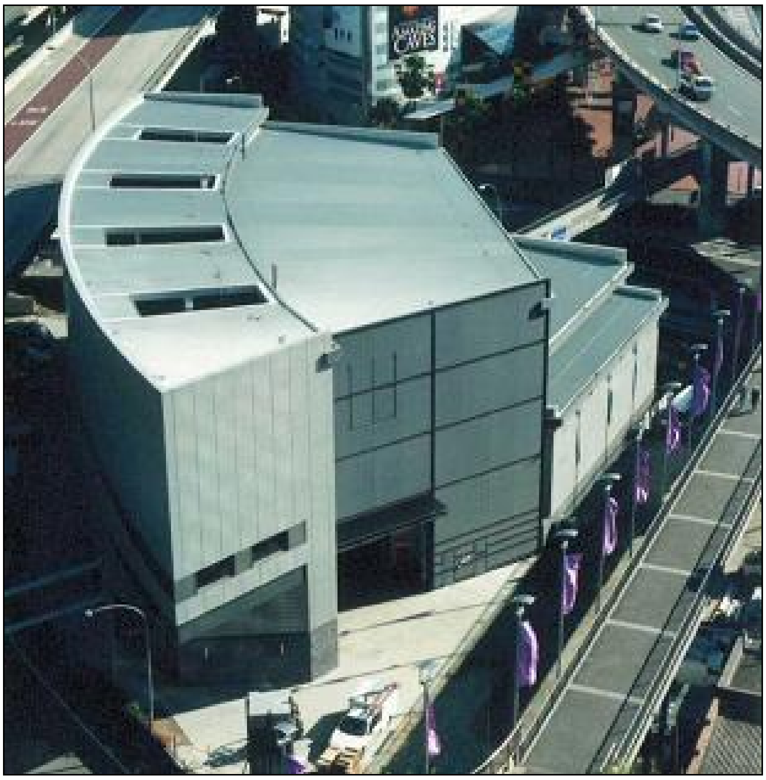
Pressure vessels containing gas, air or oil.

Environmental

Oil contamination from leakage, toxic gases from smoke and burning cabling.

3.6 Zone substations

Figure 8 Enclosed zone substation example—City Central



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 9 Open zone substation example—Homebush Bay

3.6.1 Construction

Zone substations can be totally enclosed like the City Central example in Figure 8 at Darling Harbour, or largely exposed with a security fence and buildings housing the operational functions of the substation.

All zone substations have high voltages running in and out of them, either above or below ground. Each substation has power transformers, switchgear and ancillary equipment required to feed the distribution system.

3.6.2 Security

Totally enclosed zone substations have high security entrances with solid doors that are always locked.

The outdoor type zone substations have a high security, steel fence with gates that are always locked.

Unauthorised people entering zone substations run the risk of serious injury or death from high or low voltage shock.

3.6.3 Risks

Electrical

High voltages and low voltages from incoming and outgoing supplies.

Shrapnel from exploding electrical apparatus under fault conditions.

Fire

Oil contained in large tanks used for cooling transformers and switchgear.

Pressure vessels containing gas, air or oil.

Environmental

Oil contamination from leakage, toxic gases from smoke and burning cabling.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.7 Chamber/ground/enclosed substations

Figure 10 Enclosed substation

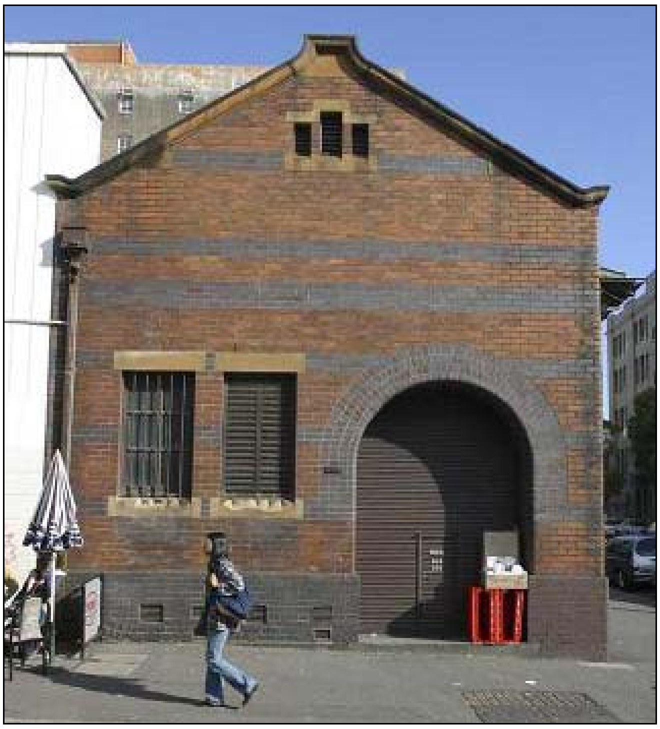


Figure 11 Ground substation

3.7.1 Construction

These substations are generally built with some form of solid brick. Some have security fences with external transformers, e.g. the ground substation in Figure 11, and some are small buildings originally built for another purpose and later converted to substation, e.g. the enclosed substation in Figure 10.

All these substations contain high and low voltage distribution systems. Each substation has powerful transformers, switchgear and ancillary equipment required to feed the distribution system (some substations are installed underground below street level).

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

The best methods for recognising these types of substations is by the electrical hazard warning labels on the walls or doors, and obviously by any substations with external transformers.

3.7.2 Security

These substations all have solid locked doors and/or security gates enclosing the electrical equipment. In the event of a fire, vehicle impact or lightning strike the electrical authority may only know of the incident if it is reported by a member of the public or an emergency service person or there is an indication of equipment failure in the Supply Authority Control Room.

3.7.3 Risks

Electrical

High and low voltages from incoming and outgoing supplies.

The high voltage equipment in substations is very well protected and unlikely to be exposed by damage to the building. However, as a standard precaution all exposed electrical equipment must be considered live and dangerous.

Fire

Oil contained in large tanks used for cooling transformers and switchgear.

There is a danger of explosion while electrical equipment is live and/or burning.

Environmental

Oil contamination from leakage, toxic gases from smoke and burning cabling.

3.8 Kiosk

Figure 12 Kiosk—External view

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 13 Kiosk—Internal view of the high voltage end

3.8.1 Construction

Kiosks are typically a secure steel or fibreglass construction sitting over a concrete pit. The colour is generally green, olive or a shade in between. In every respect, they are a miniature version of a chamber or ground substation.

Kiosks contain high and low voltage distribution systems with a transformer mounted on a concrete pit.

As kiosk construction has taken several different forms over the years, the best methods for recognising these types of substations is by the electrical hazard warning labels on the walls or doors.

3.8.2 Security

Kiosks are securely locked, but generally not alarmed. In the event of a fire, car impact or lightning strike, etc, the electrical authority will only know of the incident if it is reported or there is an indication of equipment failure in the supply authority control room.

3.8.3 Risks

Electrical

High and low voltages from incoming and outgoing supplies.

As a standard precaution, all exposed electrical equipment, including all high voltage equipment, must be considered live and dangerous. Low voltage equipment is uninsulated and may be exposed if the housing is damaged.

Fire

Oil and gas contained in tanks/bottles used for cooling transformers.

There is a danger of explosion while electrical equipment is live and/or burning.

Environmental

Oil contamination from leakage, toxic gases from smoke and burning cabling.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.9 Pole substations

Figure 14 Pole mounted substation

Figure 15 SWER pole substation

3.9.1 Construction

Pole substations are essentially a transformer with fuses mounted on an electricity power pole to convert the high voltage to low voltage for supply to residential and commercial premises.

Pole substations contain high and low voltage distribution systems.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.9.2 Security

Pole substations are exposed and are a hazard to anybody who climbs the pole or to anybody if the pole is brought down by vehicle impact, storm or fire.

3.9.3 Risks

Electrical

High and low voltages from incoming and outgoing supplies.

Transformer tank dislodged from mounting and falling after vehicle impact.

Fire

Pole catches fire, wires can drop and insulators fall off.

Oil contained in tanks used for cooling transformers and switchgear.

There is a danger of explosion while electrical equipment is live and/or burning.

Environmental

Oil contamination from leakage, toxic gases from smoke and burning cabling.

3.10 Pillar Box

In high-density areas of cities and many residential subdivisions, electrical cables run through cable tunnels or conduits under footpaths or roadways.

Transformers and switch gear for these circuits may be situated above ground enclosures or underground in concrete vaults, with access provided to each vault by an entry cover or underground basement, car parks or similar.

Figure 16 Underground power pillar

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

3.10.1 Construction

Pillar boxes are low voltage connection and control points for underground power. Older types were constructed from steel or moulded concrete while fibreglass and high impact plastic have been used in recent times.

As Telco companies, e.g. Telstra and Optus, use similar pillar boxes to supply authority pillar boxes, ensure correct identification before reporting an incident involving a pillar box.

3.10.2 Security

The covers are typically bolted or screwed to a concrete or plastic moulding with special tools being needed to remove the cover. Although the covers are not locked, they are very difficult to remove without the special tools.

3.10.3 Risks

Electrical

Low voltage underground service distribution and in some situations with 'live' uninsulated (bare) terminals and apparatus.

Fire

Plastic materials catch fire and set fire to fences and trees.

Environmental

Minimal from the pillar box cover material.

3.11 Insulators and conductors

In the electrical world, all materials are classified as either *Insulators* or *Conductors*. However, all materials conduct electricity in varying degrees.

3.11.1 Insulators

Only materials which have been designed for use on live equipment should come in contact with live conductors, e.g. line insulators and operating tools.

Although insulators will not allow electric current to pass they will break down and become conductive if too high a voltage is applied to them; a situation that can occur when an incident—such as trees in mains or car/pole impact—damages the electrical network.

Insulators

Examples of insulators—relative to a certain voltage—are:

- Pure rubber
- Glass
- Ambient air
- Porcelain
- Fibreglass
- Seasoned dry timber.

3.11.2 Conductors

Conductors readily allow current flow in large amounts, e.g. all metals. Other examples of conductors are:

- Human body
- Copper
- Aluminium
- Carbon
- Timber
- Trees

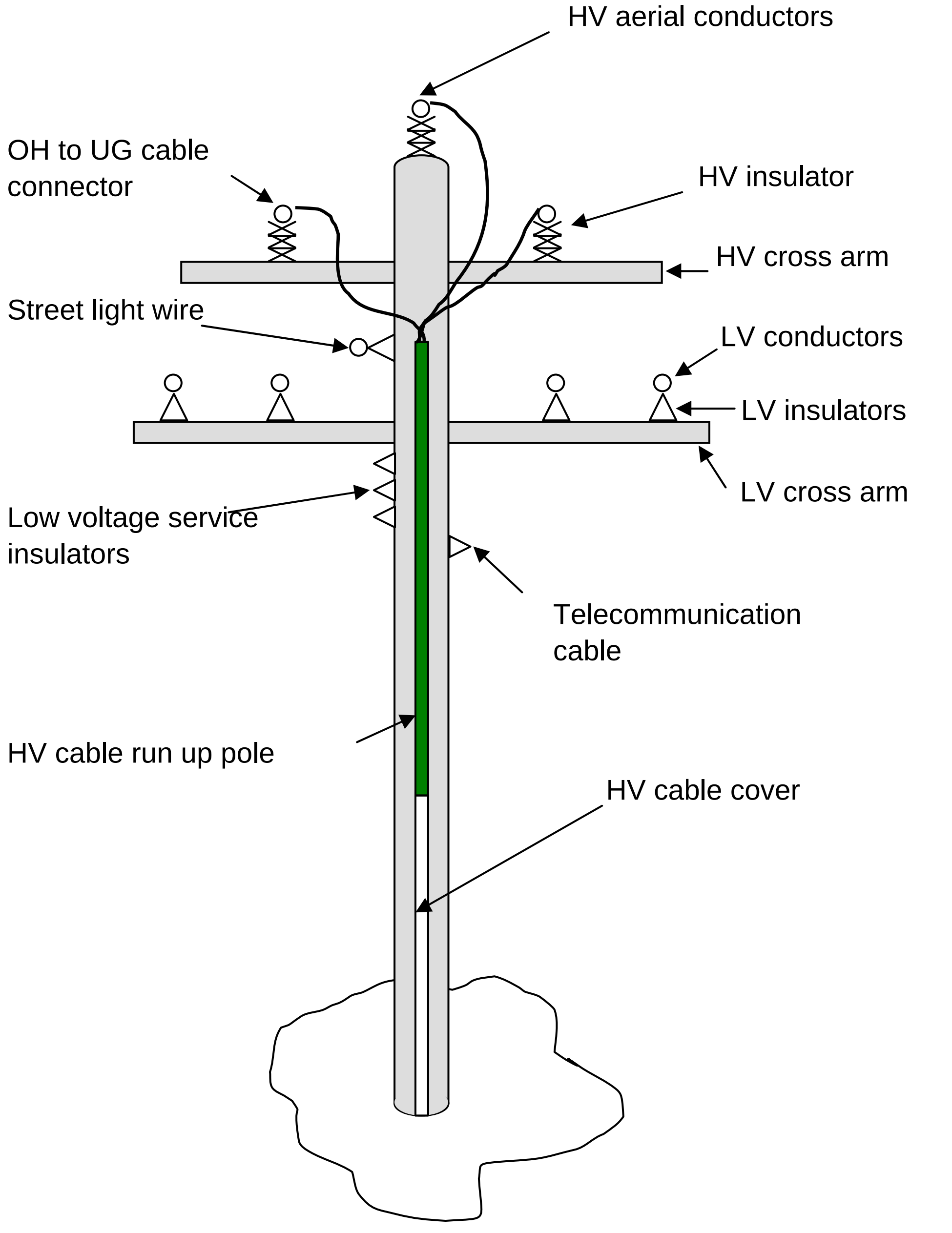
COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Steel
- Water
- Wet or dirty rope
- Flame
- Dense smoke
- Vehicle tyres
- Some fire extinguisher mediums
- Anything else that is not designed for safe use on the electrical network.

3.11.3 Distribution insulators and conductors

Regardless of the difference between poles types, the basic wiring configuration remains the same.

Figure 17 Typical pole configuration



An overhead distribution network is typically constructed with high voltage (HV), low voltage (LV), street lighting, and Telco conductors, insulators, switchgear and transformers.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Typically on the LV system, four conductors are used: one neutral and three active phases. The layout of conductors may vary depending on the area, age of the network or construction constraints. So conductors cannot be accurately identified by non-electrically trained personnel. Identifying conductors is even more difficult when they are on the ground or in trees.

Most aerial conductors in rural areas are bare copper, aluminium or steel.

Insulators

Insulators prevent electricity flowing to ground or earth.

Although they will not allow electric current to pass, insulators will break down and become conductive if too high a voltage is applied to them—a situation that can occur when an incident damages the electrical network.

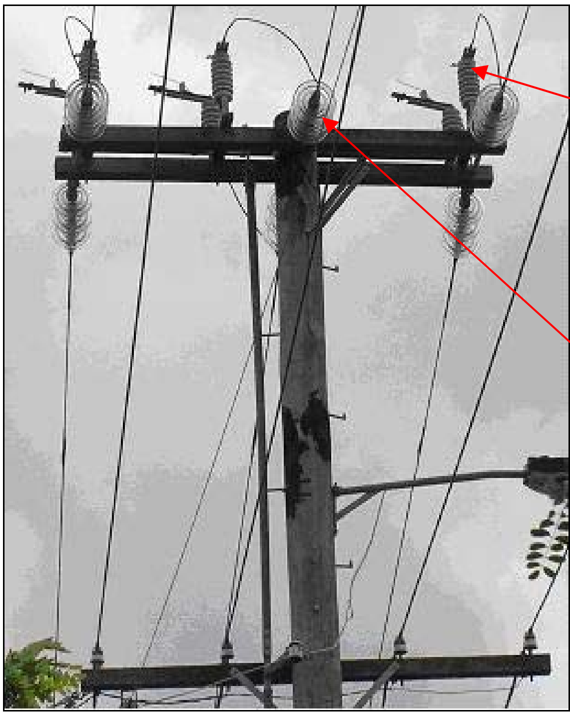
HV Insulators are:

- Typically located at the top of pole cross-arms
- Large (to handle the higher voltage).

LV Insulators are:

- Typically located at the lower level of a pole
- Smaller than high voltage insulators and about the size of a clenched fist.

Figure 18 High voltage cables and insulators



A typical high voltage pole configuration showing HV conductors at the top and low voltage below

High voltage disc insulator

High voltage pin insulator

Usually, the larger the insulator with more skirts, the higher the voltage.

Insulators are manufactured from various materials. Typically, ceramic is used as it has excellent insulating properties and is relatively easy to mass-produce.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Polymeric type insulators are slowly replacing the ceramic style insulators because of the benefits of lightweight, compact design, impact and vandal resistance, and high pollution resistance:

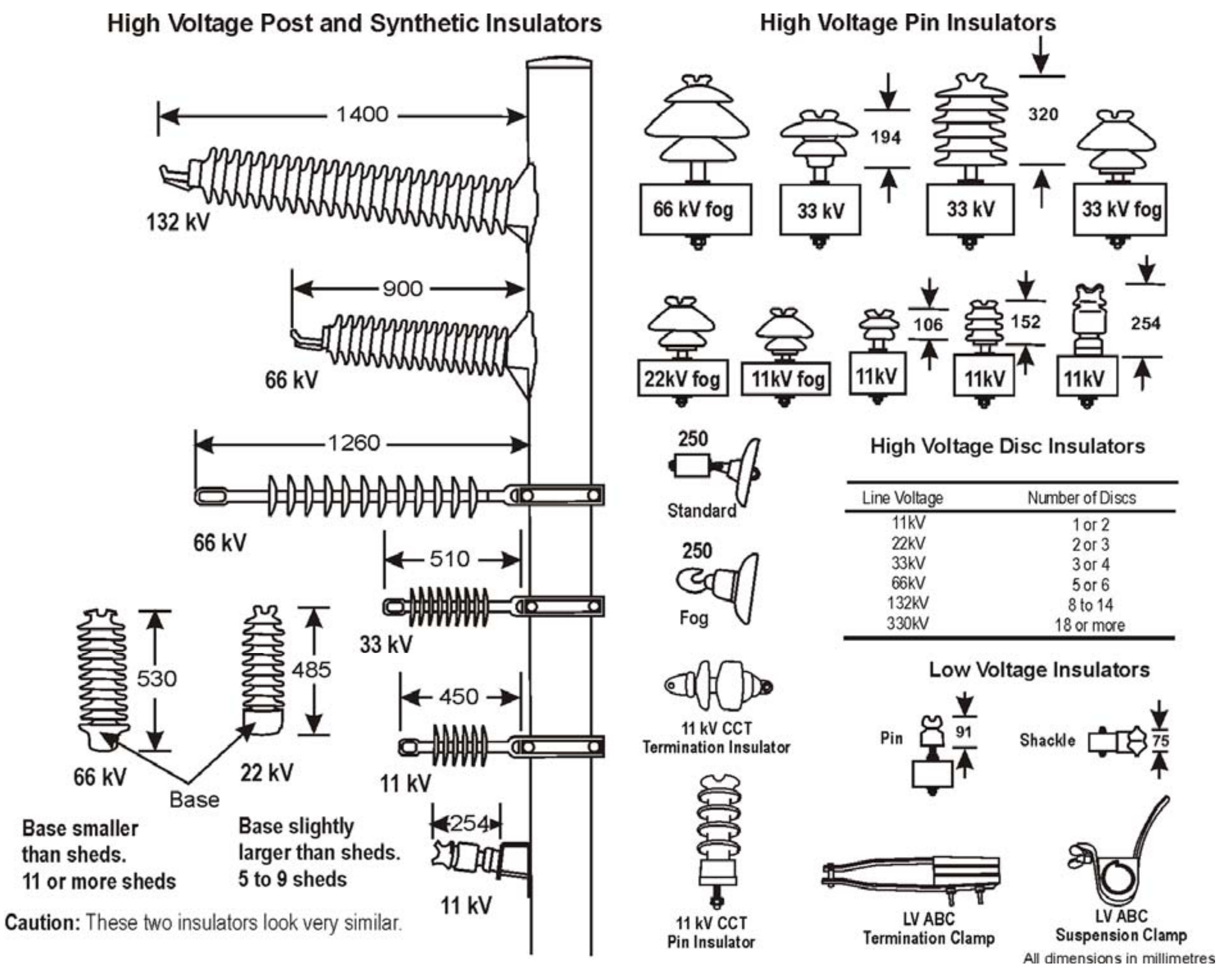
WARNING

Polymeric (plastic) insulators are much smaller than ceramic and may cause confusion when recognising voltage.

Figure 19 Post insulators

33 kV Polymeric post insulator	33 kV Polymeric tension insulator
	

Figure 20 High voltage insulator recognition diagram



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Covered conductors

Recently, covered aerial conductors have been introduced, particularly in leafy suburbs and commercial areas. Service aerials (wires between the street and house/factory) for example, are covered with cross-linked polyethylene (XLPE) insulation. Either high or low voltage street conductors may be bundled together and covered in XLPE. This construction is known as aerial bundled cable.

The misconception is that the covering (XLPE) is a touch safe insulation. In fact, due to exposure to the elements, the covering cannot be considered touch-safe. Therefore, covered conductors cannot be physically handled until they have been isolated by supply authority personnel.

WARNING

Do not regard the conductor covering as insulation.

Figure 21 ABC mains

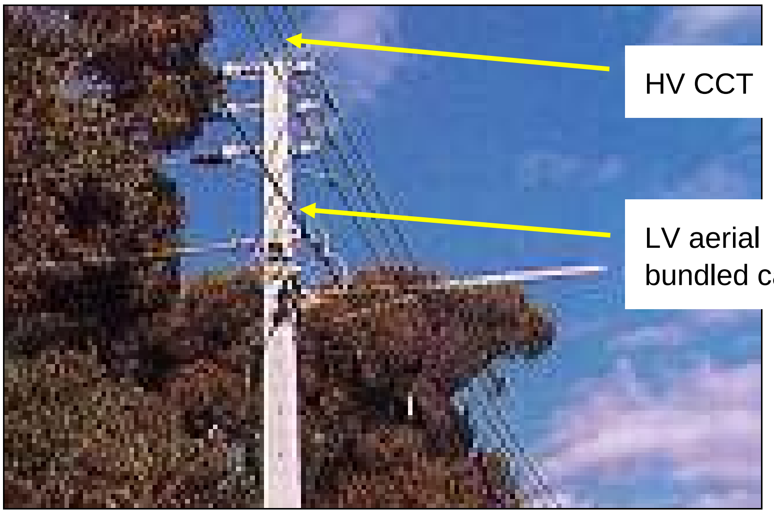


Figure 22 Low voltage aerial bundled cable

Figure 23 LV service aerial (single phase)

Figure 24 High voltage aerial bundled cable

Figure 25 HV covered conductor thick (CCT)

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 26 ABC mains

WARNING

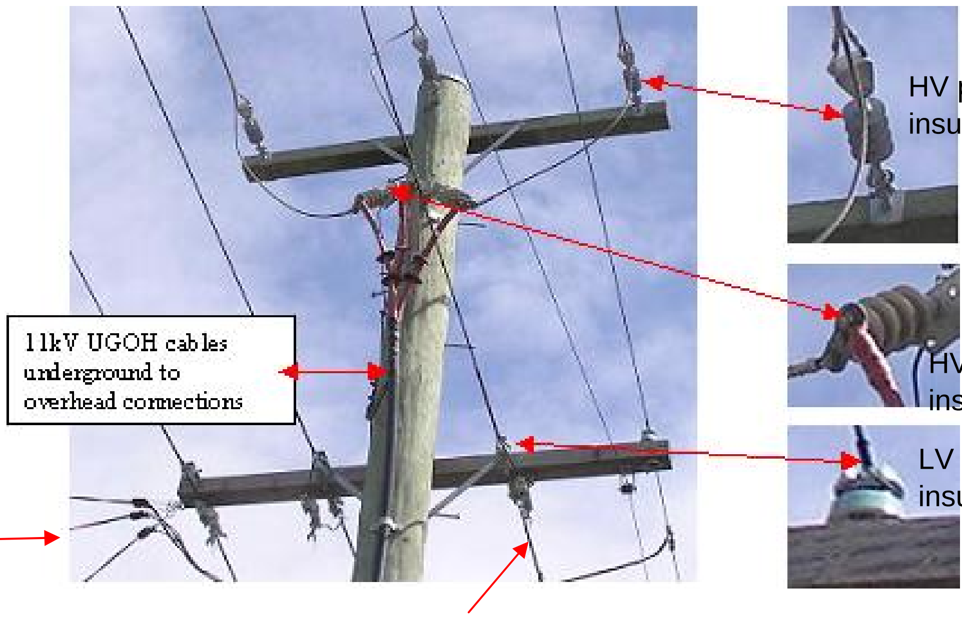
Due to the similarity of the aerial bundled cable of the electricity supply system and the broadband cabling of Optus Vision/Foxtel, which makes positive identification difficult except for industry staff, only personnel trained and authorised should handle fallen cables.

Extreme caution should be taken when any type of cable or equipment has fallen from a utility pole or is hanging lower than the height at which it was originally installed. Due to the cable's and equipment's close proximity to electrical powerlines, accidental contact with those lines could energise the cable or equipment and be extremely dangerous.

Fibre optic cable is made from fine glass strands. If the cable is damaged, minuscule fragments of broken glass can come loose and cause severe injury, e.g. by skin penetration or inadvertent transfer from hands to eyes. Also, the fibres within the cable carry pulses of laser light which is invisible to the eye but can cause eye damage if viewed directly.

3.11.4 Underground overhead connection

Figure 27 High and low voltage cables and insulators with an underground connection



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Street light conductor

3.11.5 Dangers of conductive materials

WARNING

Do not touch covered wires that are damaged or fallen, as they may not provide the necessary protection for safe handling.

You must treat all materials, including liquids and gases, as conductive.

Remember—anything can be a dangerous conductor.

Examples of unsafe conductive objects and non-ferrous materials

Under the right circumstances, many materials will conduct electricity. For example, wood, earth and concrete can be conductors if made moist with any liquid and/or contaminated by another conductive material.

Any object containing metal will readily conduct electricity and is not to be used in conjunction with electrical apparatus. For example, all the following items will conduct electricity and are not to be carried into electrically hazardous areas by hand or in clothing:

- Metal and wire reinforced ladders
- Metal and metal reinforced tapes and rules
  (most fabric tape measures are metal reinforced)
- Hand held telephones
- Tools of any type, e.g. spanners and screwdrivers, etc.

Personal items, either exposed or under clothing, are also dangerous in electrically hazardous areas and must not be worn. Examples are:

- Clothing with metal threads or metal components
- Bracelets
- Rings
- Neck chains
- Watches.

Remove any objects from your clothing or belts that are potential conductors and could fall onto live exposed conductors. Objects falling from pockets are particularly dangerous.

Vehicle tyres

Do not regard vehicle tyres as insulators of electricity. Tyres, flames and black smoke can conduct electricity.

Fire

Only use fire extinguishers which are marked Class (E), *Suitable for electrical equipment*, e.g. dry powder, CO_2 on low voltage equipment. Do not use a fire extinguisher on high voltage fires. High voltage equipment will require de-energising, isolating and earthing by the supply authority.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

The contents of other types of fire extinguishers, e.g. foam and pressurised water, are conductive and must only be used after the electrical equipment has been *isolated* by authorised supply authority personnel.

3.12 Protection systems and reclose feature

3.12.1 Introduction

Electricity supply authorities install protection systems on low and high voltage power systems to protect the power cables and the equipment connected to those cables such as transformers, switchgear etc from being damaged by faults. A similar principle applies to the fuses or circuit breakers on the domestic switchboard protecting the circuits, the appliances plugged into power points, the light fittings, the electric hot water system, air conditioners, ceiling fans, etc.

Sometimes, the protection systems installed on low voltage and high voltage power cables will not detect a line down on the ground. These same protection systems usually have a **reclose feature** which causes the circuit breaker at the substation to open and turn back on automatically after a pre-determined time. It is therefore vital to ***stand clear*** of fallen power cables until the **ALL CLEAR** is given by the electricity distributor’s personnel.

3.12.2 Zone substation recloser

At zone substations supplying OH 11 kV feeders, the protection relays and circuitry on the circuit breakers are usually arranged to automatically reclose a breaker after it has tripped.

The recloser operates after a delay of anywhere between 5 and 30 seconds to allow time for a short-term (transient) fault to clear, e.g. a tree branch blows off the line, or conductors swing back to normal after clashing. If the line is still faulty, the auto-reclosing circuit breaker will turn off automatically again and then the breaker is ‘locked out’. In addition to this, the supply authority control room can usually close the circuit breaker remotely **at any time**.

3.12.3 Pole top recloser

This type is a pole-mounted, auto-reclosing oil circuit breaker or gas insulated circuit breaker, designed for use on rural HV distribution lines supplements the auto-reclosing breakers at the zone substation. They are designed to trip faster than the zone substation feeder breaker to keep interrupted customers to a minimum.

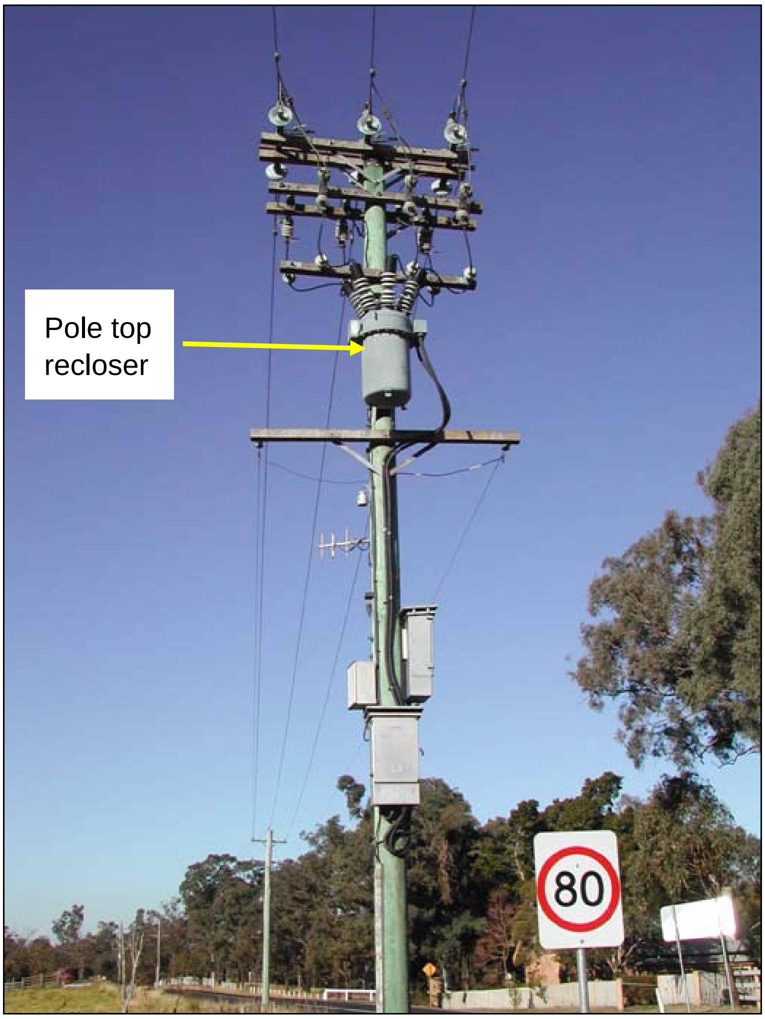
The reclose time is shorter: typically 1.5–2 seconds and they are set to reclose several times (usually a maximum of three) before locking out. Physically, they look similar in size to a pole top transformer.

WARNING

Reclosing devices may automatically re-energise a line that appears to be de-energised several times without warning. Maintain the 8 metre radius voltage gradient exclusion zone to any conductor fallen to the ground.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 28 Pole top recloser



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

4 Electrical hazards

Electricity poses a serious threat in any scene where high-voltage power cables have fallen or where wires or a damaged electrical appliance can expose people to electric currents.

High-voltage conductors may be knocked down by a vehicle colliding with a power pole, by high winds in a storm, by lightning, or by other causes. If you see fallen power cables:

- Stay back and keep bystanders at least 8 metres from the cables
- Call the electricity supply authority
- Do not try to move the cable, even with a non-conductive implement, because of the risk of the electricity arcing. Some conductors can spring back or recoil to the victim if pushed away by an untrained person
- If a fallen wire is touching a car, tell occupants to stay in the car until help arrives
- Stay clear of metal fences and similar structures or water which may be in contact with a fallen cable.

4.1 Definitions

Hazard	Anything, including work practices or procedures that can endanger the health and safety of a person. This can be anything from a slippery floor to a wall showing signs of weakness or pending collapse.
Risk	Is the chance of something happening that will endanger the health or safety of a person. It is measured in terms of probability (likelihood) and consequence.
Control measure	A measure taken to minimise risk to the lowest practical level. If a risk cannot be eliminated, it should be controlled using strategies listed in preferential order in the **hierarchy of controls**. That is: * Substitute less hazardous equipment or substance. * Isolate the hazard from the person at risk. * Engineering controls, e.g. equipment guarding. * Administration controls, e.g. develop a safer procedure. * Use personal protective clothing and equipment, e.g. helmet, gloves, SCBA, etc.

4.2 Risk assessment

To protect emergency service personnel, a risk assessment should be undertaken to develop strategies to assist in managing the incident. From an electrical safety viewpoint, a range of risks need to be considered, including the following:

- Immediate risk of electrical shock to self and others—victims or bystanders

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Risk of electric shock on moving plant or equipment
- Risk of fire or explosion from arcs and sparks
- Risk of release of toxic gases from heat or fire
- Risk of insulating gases sulphur hexafluoride (SF_6) or other gases displacing air in confined spaces
- Risk of shock from stored energy sources e.g. battery banks
- Risk of wires or other electrical equipment becoming live from unexpected sources by:
  - * Automatic, inadvertent or remote switching
  - * Induction from adjacent energised lines (not necessarily at the immediate location)
  - * Portable generators
  - * Solar panels.

4.3 General hazards

WARNING

You must treat all electrical wiring and apparatus as *live* until it has been isolated and proven to be de-energised by trained personnel from the responsible electricity authority.

All incidents involving electricity have the same common hazards and, to minimise the risk to life and property for any given situation, the same basic control measures must be followed.

4.3.1 Risks

- Contact with live wires can injure or kill.
- Equipment in contact with wires may be live and can injure or kill.
- Electrical resistance generates heat and can cause fire.
- It is impossible to positively identify if a wire is alive or de-energised by its appearance.
- Remote switching can make wires live at any time until isolated by personnel from the electricity supply authority and the area declared safe.
- A dangerous voltage gradient may exist.
- Insulation on wires may not be effective.
- Backup power sources may reactivate.

4.3.2 Control measures

Following Occupational Health and Safety Regulation 2001 (NSW), Chapters 2 and 4, risk assessments must be conducted when dealing with any incident involving the possibility of people coming in contact with electricity, where wires have fallen to the ground or onto a vehicle, truck or plant.

- Request the attendance of the electricity supply authority immediately to make the area safe.
- Always regard any wire as live until advised differently by the electricity supply authority.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Declare an 8 metre radius voltage gradient exclusion zone around all identified hazards.
- Ensure that members of the public or other emergency services personnel do not enter the exclusion zone.
- Do not venture, either on foot or in a vehicle, inside the 8 metre voltage gradient exclusion zone of an electrically hazardous area.
- Complete a risk assessment at least 8 metres away from any situation involving electrical wiring and/or equipment.

4.4 Personal protective equipment

This list is not definitive and may include other items.

Personal Protective Equipment may consist of:

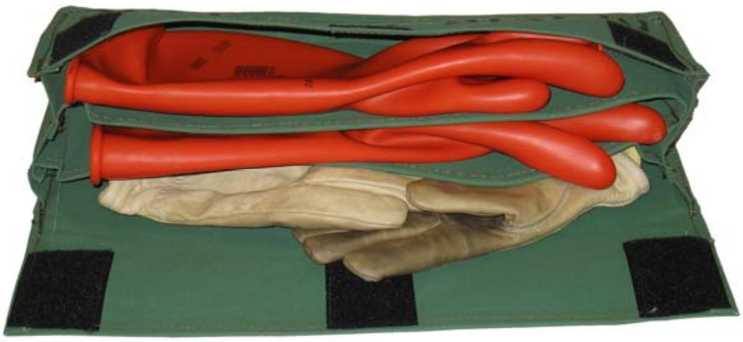
- Structural fire fighting uniform
- Orange electrical workers' gloves
- General purpose gloves
- Safety glasses or goggles
- Face shield.

4.4.1 Electrical safety kit

The electrical safety kit consists of a green canvas bag containing:

- one pair of orange electrical workers' gloves
- one pair of general purpose gloves
- a Modiewark GLM Mini Rescue voltage detector.

Figure 29 Electrical safety kit



The orange electrical workers' gloves are rated to maximum 650 V and made of a thinner rubber than previously issued electrical gloves to improve dexterity. General purpose gloves must be worn over the electrical gloves at all times to protect the rubber.

There are three separate compartments in the canvas bag and correct storage is as follows. The front two compartments:

- one each of the electrical gloves.

The electrical gloves must not be stored together or folded as any moisture on the rubber can cause deterioration and render the gloves unserviceable.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

The rear compartment:

- the general purpose gloves
- Modiewark GLM Mini Rescue voltage detector.

The Modiewark GLM Mini Rescue must be stowed in the rear compartment with the general purpose gloves so it cannot damage the electrical workers' gloves.

Figure 30 Electrical workers gloves

Figure 31 General purpose gloves worn over the top

WARNING

Orange electrical workers' gloves must be kept dry to minimise the chance of electric shock.

4.4.2 Cleaning and maintaining electrical worker's gloves

Orange electrical workers' gloves must be replaced annually whether they have been used or not. Station Commanders must record the date of receipt of new gloves in the Occurrence Book.

Old gloves must be discarded as soon as new ones are received.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

4.4.3 Modiewark GLM Mini Rescue

The Modiewark GLM Mini Rescue Tester is a universal pocket size proximity non-contact voltage detector which, when correctly set, operates in the range 50 V AC to 500 kV AC.

For full details of using the Modiewark GLM Mini Rescue Tester, refer to the Recommended Practice for the equipment.

Figure 32 The Modiewark GLM Mini Rescue Tester

4.5 Voltage gradients on the ground surface

4.5.1 Ground gradient effect

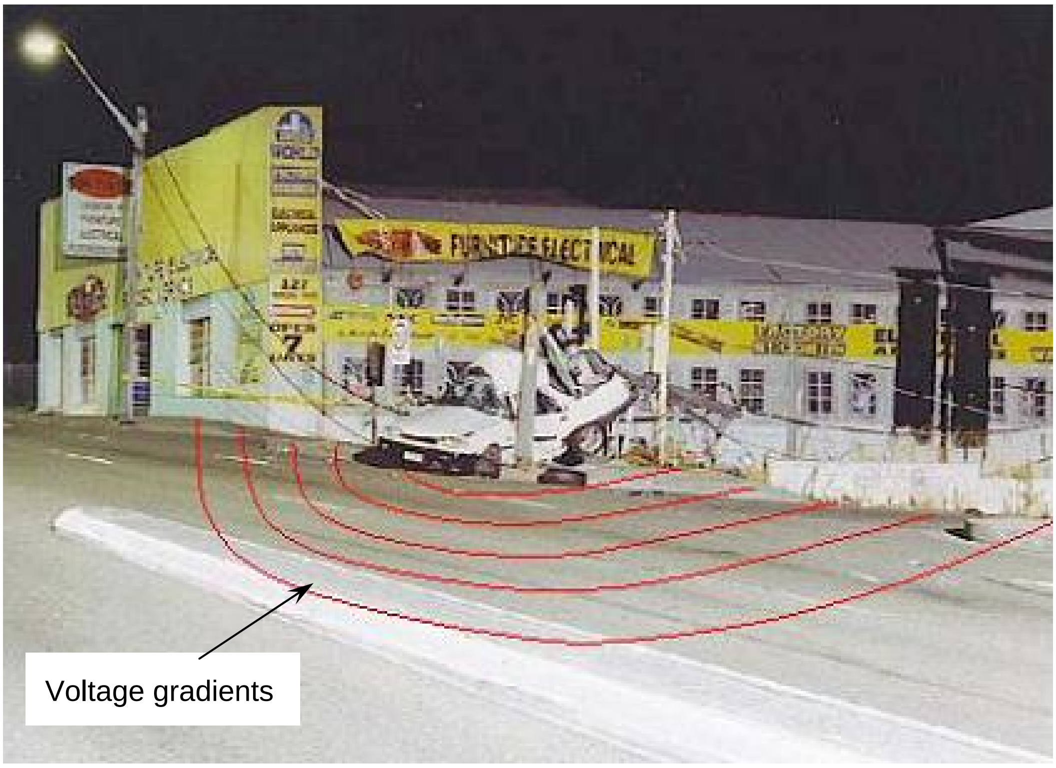
A live wire in contact with the ground creates two problems; *step potential* and *touch potential*.

Electricity always seeks the shortest and easiest conductive path to earth. However, if electricity is released onto the ground surface, such as when a *live* wire falls to the ground, the electricity will fan out from the point of contact. There is a rippling effect that can be likened to dropping a pebble into calm water. In the pool of water, the wave created at the point of contact gets smaller as it rings out. Similarly, in this *pool* of electricity, the energy is at full system voltage at the point of ground contact, but as you move away from the contact point, the voltage drops progressively. The voltage will vary depending on the composition of ground, e.g. concrete, road surface soil, etc; the moisture content; and the voltage at source level.

This effect is known as *ground gradient* and it is extremely important to understand how it works.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 33 Voltage gradient area after a vehicle impact on a power pole



The red lines on the above photograph loosely represent the invisible voltage gradient lines. The voltage gradient area also extends through the unseen region on the other side of the fence and **inside** the furniture and electrical showroom building immediately behind the accident.

As NSWFB personnel will typically not know the voltage of the grounded cables it is imperative that an 8 metre radius voltage gradient exclusion zone is established until safe clearance is given by qualified supply authority personnel.

4.5.2 Step and touch potential parameters

The values used in the following diagrams are indications only.

When calculating the step and touch potential voltage gradients the following factors must be considered:

- Moisture content
- Surface density
- Surface material
- Actual voltages being propagated, i.e. single phase/two phase.

The main message is that the risk of injury or death is greater the closer a person is to the energised source.

For OH&S purposes, a minimum of 8 metres from the electrical hazard is mandatory to ensure safety.

4.5.3 Step potential

In Figure 34 below, where a live high voltage wire has fallen to, and is in contact with, the ground, 'a ground gradient effect' will occur. If one foot was

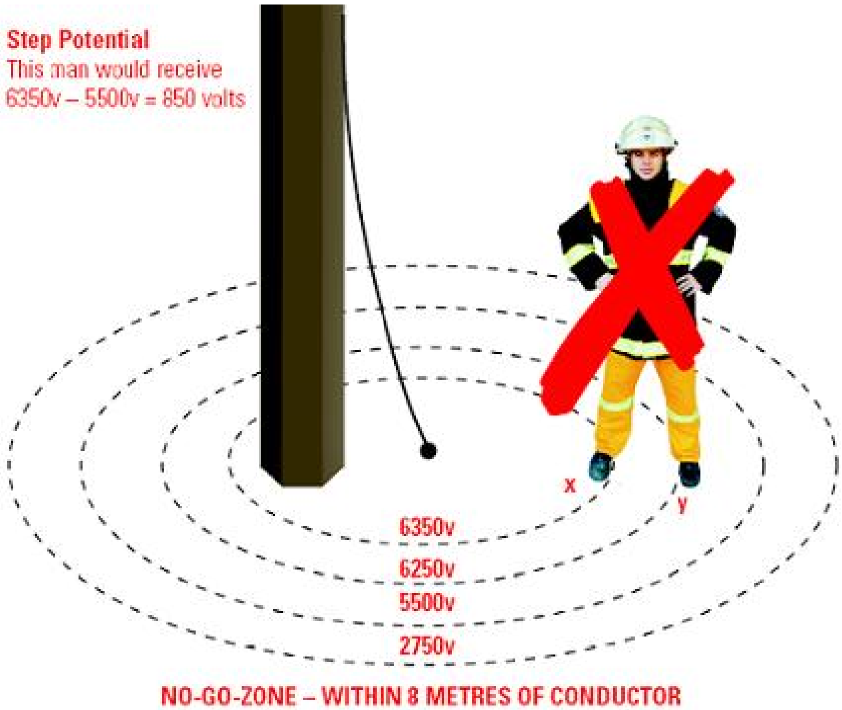
COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

near the point of ground contact (at *x* voltage) and the other foot a step away (at *y* voltage), the *difference in voltage* would cause electricity to flow through the body driven by a voltage equal to (*x* minus *y*) volts. The difference in voltage in this case is known as *step potential.*

The details in the following diagram are representative only as many factors can affect the actual voltages at any point in the gradient. How and where a person may be standing within the gradient has many variables affecting the voltage that could pass through their body.

You can avoid the danger in this situation if you stay at least 8 metres from the contact point for all voltages.

Figure 34 Step potential on a high voltage gradient



WARNING

Extremely dangerous. Do not stand or walk anywhere within this 8 metre vicinity.

The above example shows a single phase (one conductor) of a high voltage 11000 V system touching the ground. If two cables were down, the voltage could increase by √3, i.e. to the full 11000 V. Higher system voltages of 22 kV, 33 kV, 66 kV etc. would increase the ground gradient voltages.

4.5.4 Touch potential

Electricity will flow through the body if one hand or a tool being held contacts an energised electrical source. The path of electric current flow will be through the hand, arms, body, legs and feet to ground. The difference in voltage between the hand and what is being stood on, is known as *touch potential.*

You can avoid the danger in this situation if you stay at least 8 metres from the contact point for all voltages.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

As a result of an electrical incident (car hitting pole, lightning strike, etc.), there are many hidden dangers associated with equipment that is in contact with a live electrical source. The actual voltage will vary, but the following are examples of situations that, when in contact with a live electrical source present a very real danger if touched:

- Wires/cables
- Trees
- Fences (particularly metal construction)
- Cars
- Poles
- Down pipes
- Moisture
- Ground surface material
- Signposts.

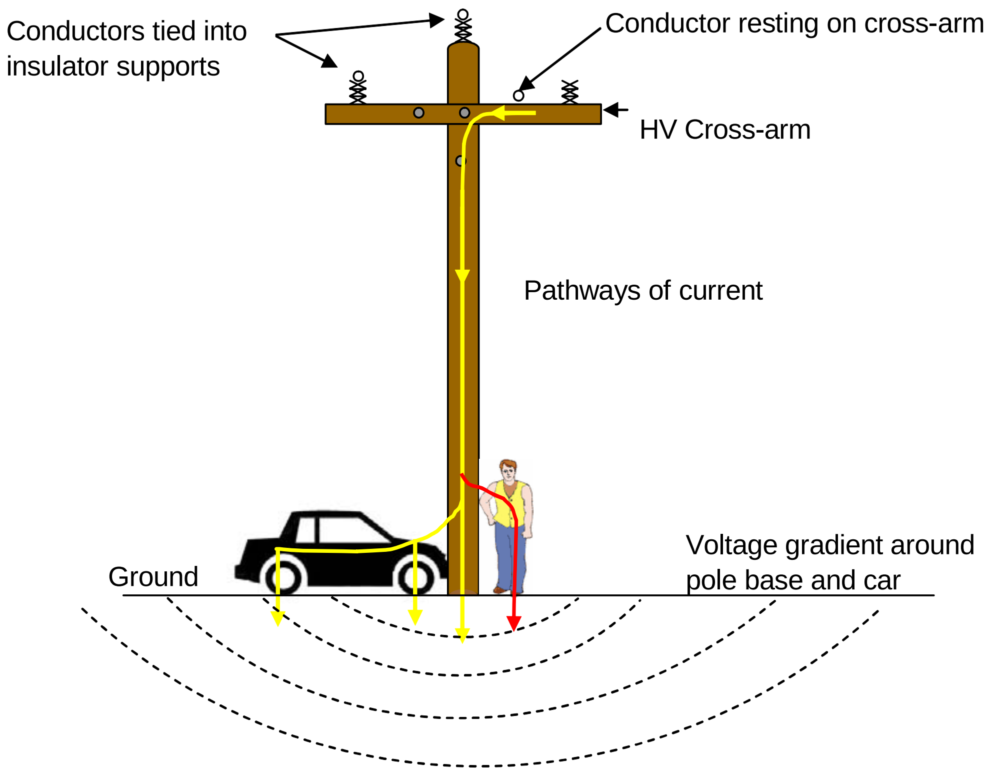
If touched, all the above, and virtually any structures exposed to an energised source, may cause death or serious injury under the right conditions.

A very dangerous situation is, as a result from an 'electrical incident' (car hitting pole, lightning strike, etc.), where an electrical conductor is dislodged from its support insulator and rests on the pole cross-arm or pole itself. The conductor most likely will be alive resulting in a pathway of electric current through the cross-arm and down the pole to earth. Any person touching the pole is at a high risk of touch and step potential.

WARNING

Always look up and check the conductors are tied into their respective insulator supports before approaching the 8 metre radius voltage gradient exclusion zone.

Figure 35 Touch potential

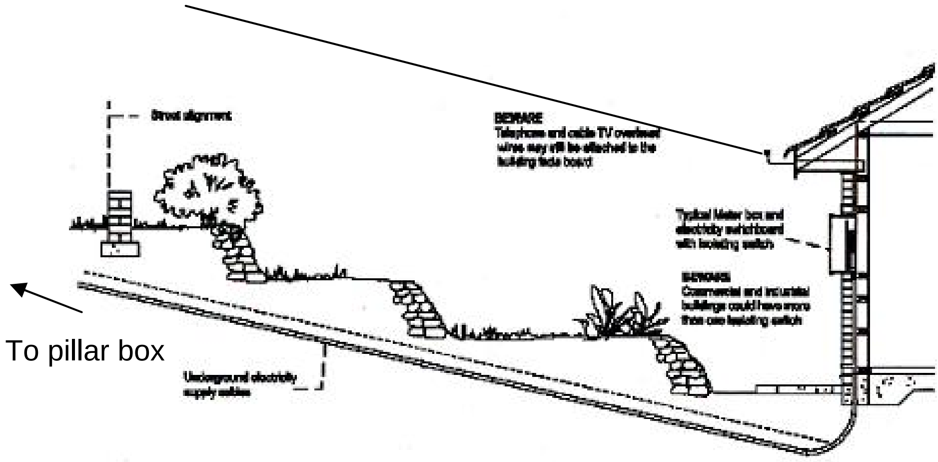


COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5 Critical incidents

5.1 Fire hazards

Figure 36 Typical domestic underground power service



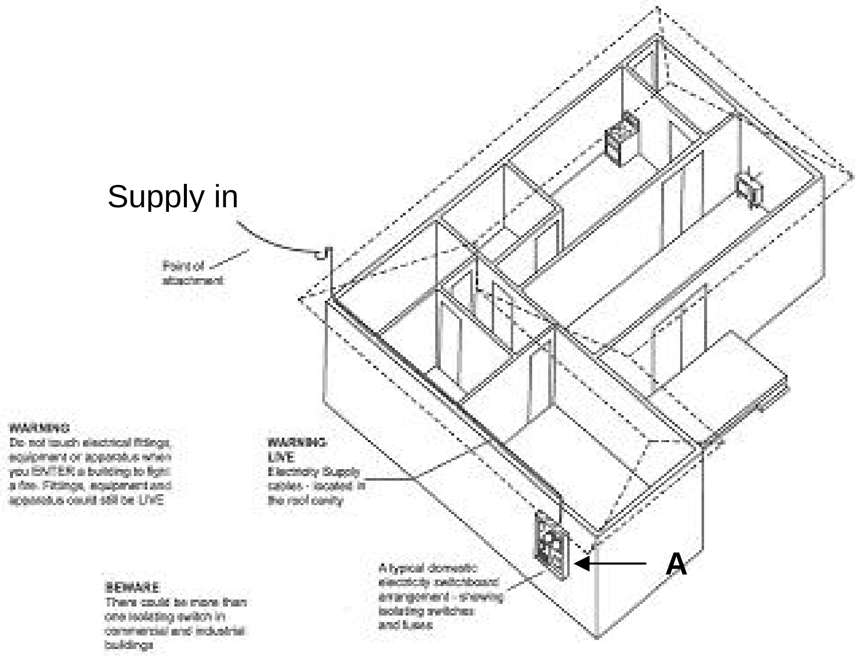
Underground service connections are identified by the:

- Quantity of overhead service wires present (or lack thereof)
- Presence of pillar boxes in the street.

WARNING

Telco cables may be present in an underground electricity supply area.

Figure 37 Typical domestic service



WARNING

Turning off the main switch (A) will not isolate incoming electricity supply from the street, whether it is underground or an overhead supply.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.1.1 Building fires

Electricity service is supplied to homes at 240 or 415 volts. Voltage to industrial plants and commercial buildings may be 240 or 415 volts, but can be 11 000 volts or higher in large industrial installations and high rise.

WARNING

Do not cut wires at the pole or point of attachment (POA) under any circumstances. Cutting wires must only be done by an authorised person.

5.1.2 Isolation procedure for domestic 240/415 volt switch boards

1. Ensure area surrounding switch board is safe to approach.
2. Don electrical workers' gloves.
3. Don general purpose gloves over the electrical gloves.
4. Open meter box.
5. Isolate power by turning all main switches to the OFF position.

WARNING

There is no limitation to the number of main switches. All circuit breakers and switch-type mechanisms should be turned OFF within any main switch board.

When isolating power, overloaded power circuits may arc causing a flash. Therefore it is important to have your helmet visor down and to turn your eyes away from the switch board.

6. Remove all fuses and place each fuse directly below the fuse holder for future reference and pending investigation.
7. If circuit breakers are installed, note on/off position and then switch OFF.
8. Send a general broadcast to all personnel at the incident that power has been isolated at the **switch board**.

WARNING

This does not guarantee that power in the building is isolated. The power may still be live, e.g. illegal wiring, additions to the building which have resulted in the relocation of the switch board, POA located some distance from the switch board and consumer mains still running through the roof or wall cavity of the structure which has contacted internal wiring.

9. Request the attendance of the electricity authority.
10. IC conducts size up of building to locate POA and other power sources at the incident. Note all power sources on the dynamic risk assessment.
11. On conducting size up, if the IC is not completely satisfied with the isolation at the switch board, he/she may have to consider withdrawing to defensive mode until the appropriate electrical authority or site electrician arrives.
12. Advise all personnel at incident by radio when the power is disconnected.
13. Follow all safe working practices relating to electricity during firefighting operations.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 38 Standard domestic switchboard (without metal meter box)

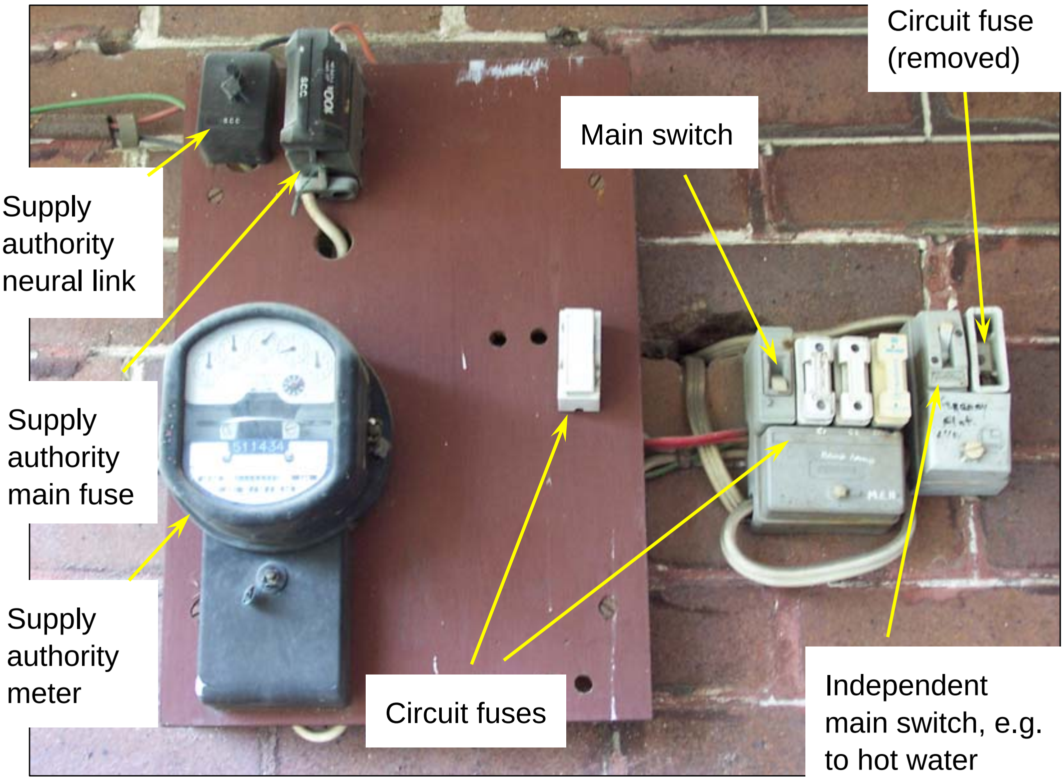
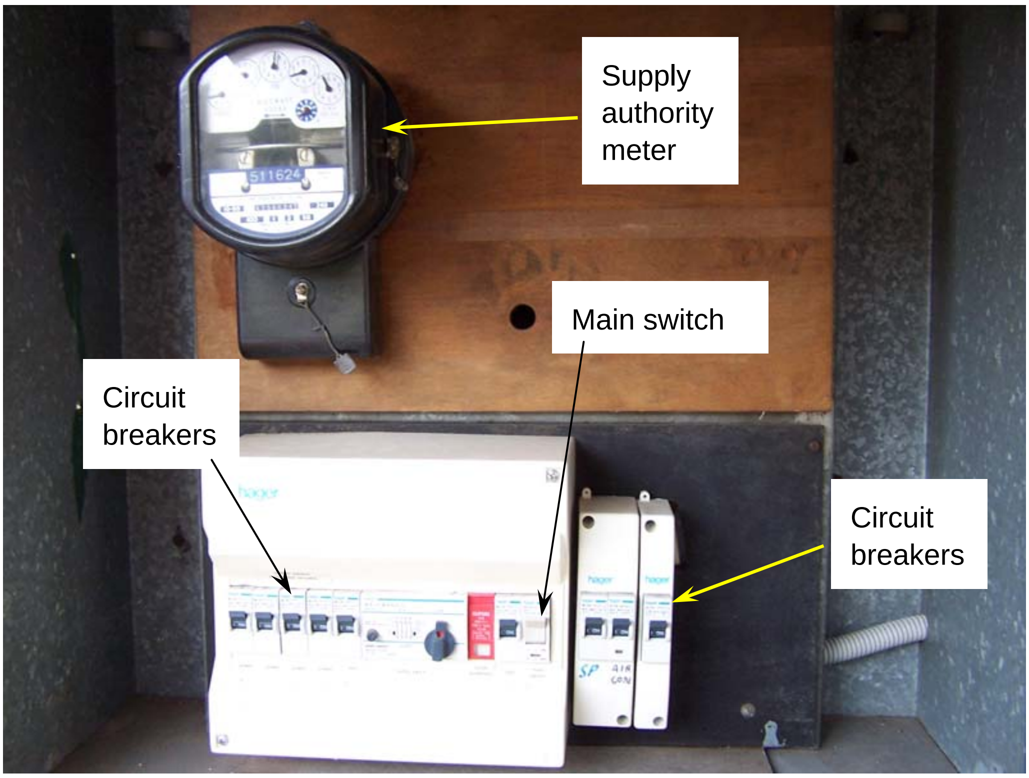
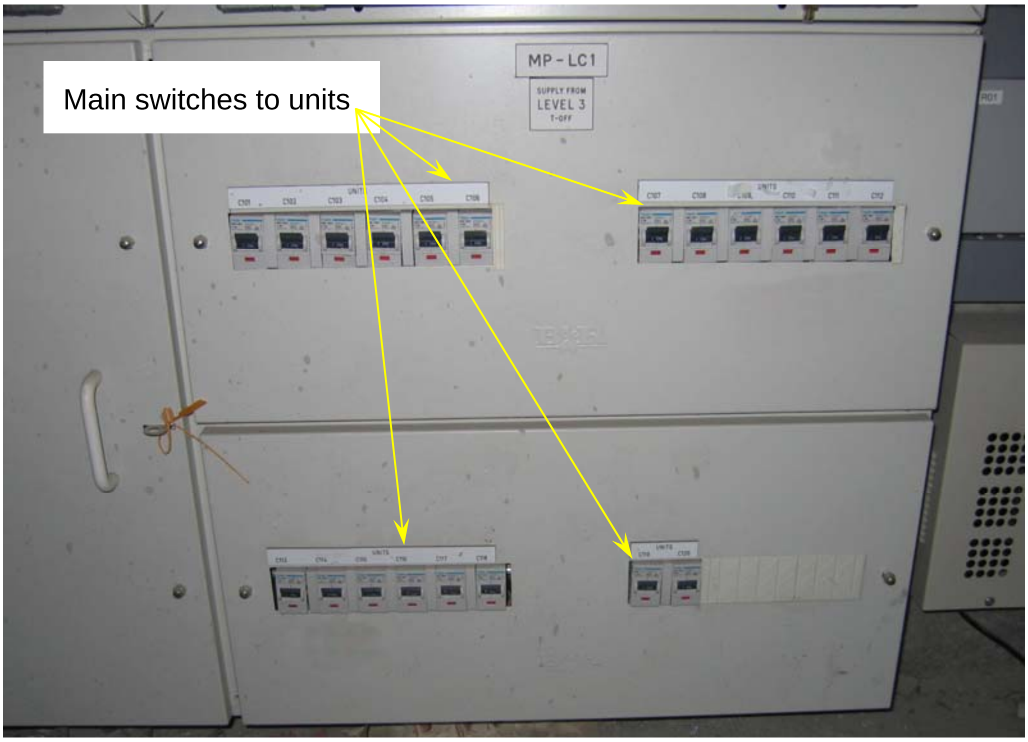


Figure 39 Standard domestic switchboard (inside metal meter box)



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

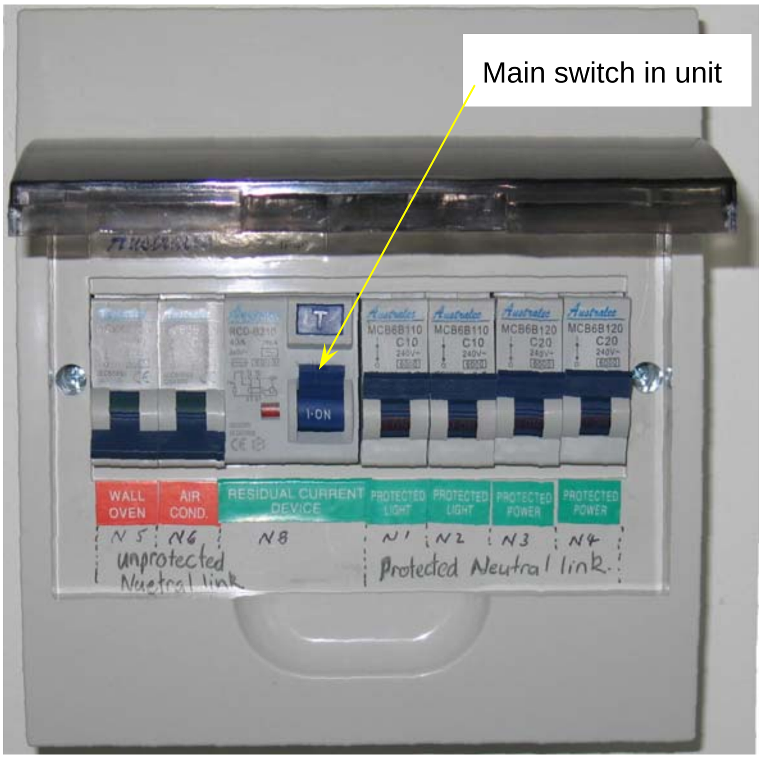
Figure 40 Apartment block distribution board to units



NOTE

This board is usually behind a locked door and may not be accessible.

Figure 41 Unit switchboard (usually in cupboard in unit)



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

WARNING

Check with the IC before reconnecting the power supply.

The following risks and control measures apply.

Risks

- Melted insulation or building damage may cause any conducting material to become live.
- Lights, lifts and similar building services may fail unexpectedly.
- Power may still be active in the building after isolation at main switch.
- Be aware that there may be more than one main switch.

Control measures

- Ensure members of the public or other emergency services personnel are prevented from approaching the hazard.
- Isolate all lights and power if it is deemed to be a hazard.
- Apply standard safe working practices for buildings.
- Do not park appliances beneath overhead cables.

WARNING

Opening switches under normal conditions is not hazardous; however during fire fighting the operations may have additional risks and require control measures.

The fire may introduce a fault condition that can overload the switch during operation.

Electrical hazards are increased when flooding and wet conditions exist in buildings. Any open wires (even low voltage) can be lethal if you are in contact with the live wire and the wet ground. Extreme caution is called for in this situation. The only safe way to enter is to isolate the power before you enter the building.

5.1.3 Electrical safe working practices

Notify the IC of any electric shocks, however minor, and any wires arcing immediately they occur on the fire ground. This will maximise safety for all firefighters at the incident.

When feeling your way in smoke and darkness, protect the face behind the crook of the arm with the back of the hand outwards. See Figure 42. This will prevent your hand closing on live electrical wires IF encountered.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 42 Feeling your way through smoke

When working around electrical hazards, there are some common safe working practices that you should follow. These are:

- If you find an electrical hazard, inform your crew members and the IC.
- Avoid stepping on or accidentally brushing against or bumping wiring or energised objects.
- Be aware of dislodged overhead wiring brushing against your helmet.
- If a wire is broken, locate both ends to decide the size of the danger area.

Safe working distances

- When working around fallen wires, keep 8 metres away from the point where the wire contacts the ground because the ground can be energised.
- Ensure hose lines and equipment should not be dragged across or placed within this 8 metre area as electric shock may result.

Conductors

- Ensure that ladders and hose lines are not allowed to come in contact with metal objects such as gutters or fences that may be energised by fallen power lines.
- Puddles, damp ground, wet flooring and any other wet or damp surfaces can become energised.
- Avoid applying water to electrical hazards. Water is a conductor and will increase the risk and the hazard area.

Casualty in contact with a live electrical conductor

- If you encounter a person in contact with a live electrical conductor, do not become a casualty yourself.
- Determine whether the person is in contact with high or low voltage electricity by looking at the type of machinery, plant or cable diameter.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

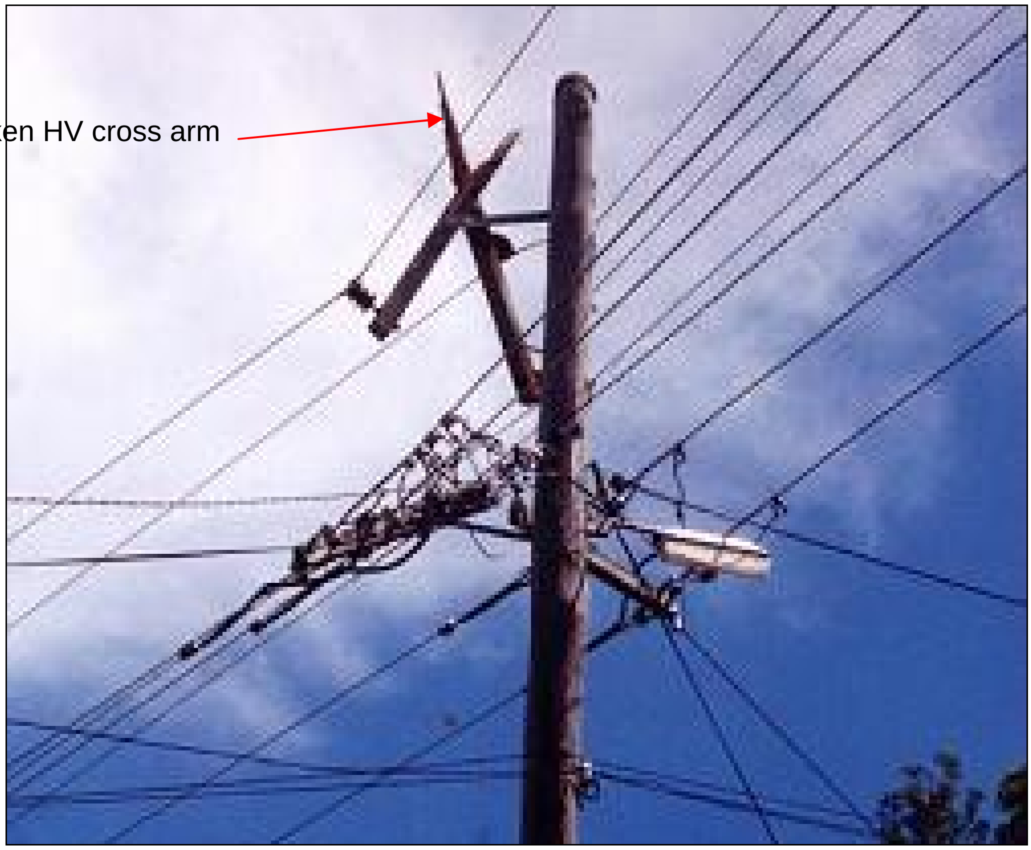
- If the person is in contact with high voltage electricity, you must wait until the power supply authority disconnects the supply.
- Do not attempt to touch the casualty.
- If you are certain that the casualty is in contact with low voltage electricity, do not touch the person.
- You may be able to assist providing you follow specific precautions. If you can quickly identify and safely disconnect the low voltage power source, do so, e.g., pull out a fuse or turn a switch off. If the power cannot be isolated, it may be possible to:
  - * Drag the casualty clear by grabbing only dry clothing, avoiding contact with the skin.
  - * Use a dry, insulated, non-conducting material such as a belt, towel or a piece of wood to drag or push the casualty clear.
  - * Be alert for metal buttons, studs, buckles and jewellery because these are conductors.

5.2 Damaged support structures and wires under tension

Figure 43 High voltage transmission cables in an electrical storm

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 44 Pole damage—storm



The following risks and control measures apply.

5.2.1 Risks

Additional tension on wires and or support structures could result in subsequent failure and personal injury from recoil of broken wires, further collapse of support structure or falling electrical apparatus.

5.2.2 Control measures

Damage to structures may cause additional tension on wires. In this situation, the wire may be damaged and could be all that is supporting the badly damaged structure. If any of the wires fail, the structures can fall in any direction. Keep well clear and notify the supply authority.

WARNING

Fallen high voltage or low voltage conductors that appear to have no electrical connection at the fault site may in fact be energised from an 'intermix' situation remote from the fault site.

The high voltage and/or low voltage conductors may also be alive simply from their proximity to other live conductors. This is known as induction.

Always regard the conductor on the ground or vehicle as alive!

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.3 Fallen wires

The following risks and control measures apply.

5.3.1 Risks

- Wires could be broken and both ends could remain live.
- Wires under tension may move or break, extending the hazardous area.
- While not obvious, adjacent wires or equipment may be damaged.
- Wires in contact with vehicles, fences or other conducting objects may extend the hazardous area.
- Hazards may change as a result of subsequent movements (e.g. caused by wind) or equipment failure.

5.3.2 Control measures

- Locate both ends of broken wires but do not approach them.
- Consider these hazards when determining the 8 metre radius voltage gradient exclusion zone.

5.4 People in contact with live wires or equipment

The following risks and control measures apply.

5.4.1 Risks

- If a person is in contact with live wires, all parts of the person's body will be at the same voltage as the wire.

5.4.2 Control measures

- Request the attendance of the electricity supply authority.
- Always regard fallen conductors as live until advised otherwise by the electricity supply authority.
- Maintain 8 metres clearance.

A rescue can only be attempted if the rescuer:

- Is trained in low voltage rescue.
- Has the appropriate rescue equipment.
- Is certain the person is in contact with low voltage only.

5.5 People trapped in vehicles by fallen wire

The following risks and control measures apply.

5.5.1 Risks

- Risk of fire due to sparks or heat, dangerous goods loads or spilled fuel.
- Tyres may get hot and eventually burst—up to 24 hours later. (This may occur some time after the voltage is removed.)
- Hazards could change as a result of subsequent movements (wind) or equipment failure.
- De-energised mains may at anytime become re-energised.
- Coming into contact with the vehicle and the ground at the same time while exiting the vehicle.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Vehicle could be live or become live by remote switching.
- If a train or tram is involved, State Rail Authority or Sydney Light Rail overhead cables may be present.
- Extent of wires in contact with long vehicle is not easily ascertained.
- Multiple passengers increase likelihood of panic.
- Train and tram tracks can become live.
- Subsequent movements (wind) or equipment failure may change risks.

5.5.2 Control measures

- Check there are no fallen wires touching or **under** the vehicle.
- Advise occupants to remain in the vehicle until wires are made safe.
- Instruct driver to drive vehicle clear of wires if safe to do so.
- HV wires dislodged from the insulators and touching the pole can cause the pole to become live. If a car is in contact with the pole, the car can also be live. Check that wires are not in direct contact with the pole or cross arm or any metal fixture. If wires are in direct contact with the pole, establish an 8 metre radius voltage gradient exclusion zone.
- If a train or tram is involved contact the State Rail Authority or Sydney Light Rail to determine if fallen wires are live.
- If the risk of remaining in the vehicle is greater than the risk of leaving, e.g. the vehicle is on fire, advise occupants to jump clear of vehicle and not to touch the vehicle when their feet come in contact with ground. Also advise the occupants to keep their feet together and 'bunny hop' or shuffle to at least 8 metres away from the vehicle.

WARNING

Both the *bunny-hop* and *shuffle* method of escape must only be suggested and used as a last resort as the risk of injury or death is still very high.

- Do not attempt any rescue or clean-up operations until the area has been declared safe by the responsible electricity supply authority.

5.6 Vehicles in contact with electricity kiosks

Kiosks are metal or fibre-glass boxes, installed at ground level, which contain equipment normally associated with underground electrical installations. They normally contain equipment at 415 V.

The following risks and control measures apply.

5.6.1 Risks

- Fire or explosion from oil filled equipment in kiosks and toxic gases from burning PVC insulating materials.
- Contact with high and low voltages near or under the vehicle.

5.6.2 Control measures

- Carefully inspect crash site to ensure vehicle is not lying over electricity kiosk or live cables.
- Treat the vehicle as live.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Advise occupants to remain in vehicle until situation is made safe.
- If the risk of remaining in vehicle is greater than the risk of leaving, e.g. vehicle on fire, advise occupants to jump clear of vehicle and not to touch the vehicle when their feet come in contact with ground. Also advise the occupants to move away from the vehicle using 'bunny hops' or shuffle. Refer Section 4.5.2 Step and touch potential parameters.
- Increase the 8 metre radius exclusion zone to address risks from toxic gases.

5.7 Electrical network incidents

5.7.1 Electrical substation fires

There are many dangers within electrical substations such as high and low voltage power sources, large volumes of oil in apparatus such as transformers and switchgear. There could also be sources of compressed gas such as air, nitrogen (N_2), carbon dioxide (CO_2) and sulphur hexafluoride (SF_6). In addition, battery rooms are sources of hydrogen (H_2) and diluted sulphuric acid (H_2SO_4) in large quantities. Some substations have two battery rooms.

Coupled with all of these hazards are numerous cable trenches and ducts with PVC insulated cables that will give off dangerous chlorine (Cl) gas if burning.

All of these situations will govern what a risk assessment needs to consider and should include the following points:

Entry to substations

Contact your ComCen, advise them of the location, and request the assistance of the electricity supply authority. **Do not** attempt to enter a substation to fight the fire.

Electricity distributor's direction

Wait for approval and direction from electricity distributor personnel at all times before attempting to extinguish a substation fire. This includes isolating CO_2 extinguishing systems.

Clearance to enter

The electricity distributor's personnel will give entry clearance to extinguish fires only when the apparatus has been isolated and earthed.

Pressure vessels

The distributor's personnel will advise the location of any pressure vessels containing compressed gases to be checked in case of possible explosion. Where these pressure vessels exist, the building should have Hazchem signage.

Oil hazard

Apparatus such as transformers and circuit breakers contain substantial quantities of oil requiring specialist fire extinguisher systems. A large transformer could contain thousands of litres of oil. Consideration of environmental impact should also be considered.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Toxic gases

SCBA is necessary because of the oi1, stored gases, batteries and the large number of PVC insulated cables that give off toxic gases. Do not enter substations without SCBA.

Automatic fire extinguishing systems

Some larger substations have automatic water sprinkler and/or fire extinguishing CO_2 systems. In transformer bays, the system could be an atomised water sprinkler system which, as well as saturating the fire area, is dense enough to reduce the air quantity in the sprinkler area which helps reduce combustibility.

CO_2 extinguisher systems are installed in some control buildings to extinguish low voltage control wiring fires. In the case of the CO_2 systems, there is normally a system isolation switch just inside the entrance door. If breathing apparatus is not available, the CO_2 system should be isolated. The electricity supply authority personnel will explain how to isolate fire systems.

The risks and control measures that apply to substation fires are outlined in Section 3.6 Zone substations.

Control measures

Establish an exclusion zone and do not enter the substation. Wait for the arrival of the electricity supply authority personnel. They are trained in the use of the specialised substation fire fighting apparatus and can identify the areas that have been isolated and rendered electrically safe.

Do not spray the fire with water or any other liquid until the area is made safe.

Protect the surrounds and wait for supply authority personnel.

5.7.2 Fire suppression systems

The substation fire suppression systems can vary depending on the type of substation. The fire suppression systems described for each of the common substation types below are typical.

A modern city zone substation

For example, City Central Zone Substation. Fire system equipment consists of:

- Automatic high velocity water spray fire extinguishing systems serving each individual zone transformer.
- Automatic fire sprinkler system serving the whole of the cable basement.
- Aspirating type smoke detection system, such as VESDA™, serving all areas.
- Portable fire extinguishers installed throughout.
- Fire hydrants.
- Fire hose reels.

Older city zone substations such as City North, Dalley Street, City South and City East have automatic high velocity water spray fire extinguishing systems to serve each zone transformer. Smoke detection is not currently provided.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

A distribution substation—City basement type

The substation contains an array of nozzles installed in a system of fixed CO_2 pipe work connected to a wall mounted or footpath CO_2 connection box. In a fire, the fire dampers installed in the inlet and exhaust ventilation openings close and CO_2 is injected from a NSWFB CO_2 tender or other bulk CO_2 carrier.

Portable fire extinguishers are installed.

Older underground type substations

The substation chamber contains an array of nozzles installed in a system of fixed CO_2 pipe work connected to a wall mounted or footpath CO_2 connection box. Ventilation is provided through openings in the roadway. In a fire, the ventilation openings in the roadway are covered with mats and CO_2 is injected from a NSWFB CO_2 tender or other bulk CO_2 carrier.

Portable fire extinguishers are installed.

Figure 45 Wall mounted access box for CO_2 injection

Figure 46 Wall box opened

'12' indicates number of CO_2 cylinders to be injected

Figure 47 Ground level access box for CO_2 injection

Figure 48 Access cover opened

'6' indicates number of CO_2 cylinders to be injected

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.7.3 Fires and explosions in underground electrical vaults and tunnels

In high-density areas of every city, and in many residential subdivisions, electrical distribution cables run through cable tunnels or conduits located under footpaths or roadways.

Transformers and switch gear for these circuits are situated underground in concrete vaults, with access provided to each vault by an entry cover at ground level or through access doors and stairwell.

The following risks and control measures apply.

Risks

- Electrical failure of a cable may result in an explosion or fire, which could damage insulation and make all metal parts within the vault live.
- Fires involving overheated live electrical cables in underground cable tunnels can heat aboveground surfaces and produce smoke and toxic gases.
- Accumulation of explosive and toxic gases may damage your lungs unless correct SCBA is used.
- Covers or doors to the underground vault or tunnel may blow clear.

Control measures

- Do not approach or park a vehicle over an entry cover (open or closed) due to the risk of explosion.
- Treat all below-ground substations, tunnels and pits as confined spaces.
- Use appropriate confined space procedures.
- Exclude all people, including fire fighters from the immediate area and maintain a hot zone of at least 8 metres.
- Eliminate all ignition sources and use only intrinsically safe equipment in the hot zone.
- Request the attendance of the energy supply authority.
- Keep CO_2 extinguishers and charged hose lines at the ready.
- Ensure all fire fighters are wearing structural fire fighting PPE at the incident and SCBA when entering the hot zone.
- Use gas detectors and, where available, thermal imaging cameras.
- Consider requesting HMRU, bulk $CO_{2,}$ or other specialist.
- Ensure NSWFB personnel do not enter nearby underground or basement substations without an electricity supply authority representative.
- Render the incident safe and/or hand control to a responsible authority.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.7.4 Fire fighting near high voltage powerlines

WARNING

Smoke and flames are conductive.

Smoke and flames from a bushfire or a burning vehicle in close proximity to distribution or transmission cables (conductors) can flash over. This means the smoke and flames can jump the gap between the cables (conductors) and travel down the smoke or flame path to earth if the smoke density or flame carbon content is sufficient to allowing arcing.

Typically:

- Only high voltages (11 kV and above) will flash over.
- Lower distribution voltages are unlikely to arc to ground.

Transmission tower construction

High voltage tower construction is based upon the span length required for the prevailing environment. For example, the cables may run across gullies and bodies of water, and/or run along hillsides and in forests. The directional angles of the cables are also an important consideration for the cable tension required and the resulting strain on the towers.

Most of the towers currently used support the 132 kV and 330 kV transmission voltages. However, a 500 kV transmission system runs between the Central Coast and Wollongong via Sydney.

The following risks and control measures apply.

Risks

- Sagging wires due to failures or high temperature.
- Wood pole structures may fail causing wire to fall.
- Flashover may occur between wires or from wires to ground through burning vegetation - this may be seen as a flash or heard as an explosion (fire and dense smoke are conductive).
- Poles treated with green copper chrome arsenate (CCA) give off toxic gases when alight or smouldering.

Control measures

- Do not directly attack fires in cleared areas beneath aerial conductors.
- Do not spray solid stream water directly on or near wires or insulators from the ground or air.
- Wait for fire to burn clear of the cleared areas beneath cables (conductors) before commencing a mop up operation.
- Treat conductors as live at all times until cleared by the electricity supply authority on site.
- At all times keep personnel and vehicles a minimum 25 metres clear of a head fire, or flank fire burning under or within 25 metres of aerial cables.
- When working near or under live power cables (conductors), only approach closer than 25 metres of the fire edge to conduct mop-up of grass fires. Mop-up may include knockdown of low (less than 2 metres

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

high) isolated flames/spots/smouldering logs which are not producing a convection column or heavy smoke plume.

In such cases:

* Never direct the hose stream into the power line.
* Never direct the hose stream into a smoke plume near, i.e. less than 25 metres, or reaching cables. Keep water stream no higher than a person's head height.
* Never direct the hose stream at a burning bush or tree (more than head height) in a power line easement.

WARNING

Bushes or trees burning in power line easements, and the smoke and flame from them, present a real threat of a flashover to earth from the wires—keep at least 25 metres clear.

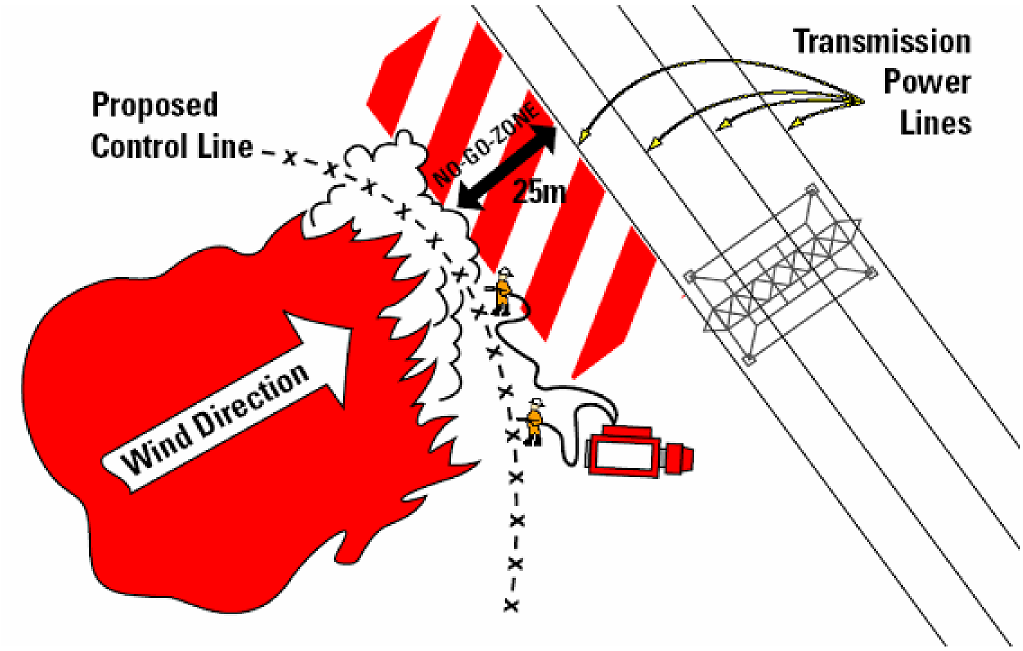
- When crossing power line easements, ensure there is adequate clearance between the highest point of the vehicle (including aerials) and the power cables, avoiding areas with tall vegetation under cables (conductors).

Prescribed burning near energised cables

Major powerlines are critical infrastructure. They support essential community services and cannot be de-energised without having an impact on public safety. It is preferable to not attempt prescribed burning (hazard reduction) activities near energised cables where possible.

Where prescribed burning in the cleared area under cables is necessary, early advice to the electricity supply authority will allow an assessment of risks associated with de-energising the line.

Figure 49 Fire proximity to high voltage cables



COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.7.5 Pole fires

The following risks and control measures apply, remembering pole fires may occur at pole top or ground level.

Risks

- Poles, electrical apparatus and timber cross-arms could fall.
- Live wires could fall on personnel or vehicles.
- Fire could spread from base of structure.
- Poles treated with green CCA give off toxic gases when alight or smouldering.
- Poles may be energised at high or low voltages via insulator breakdown.

Control measures

- Contact the relevant supply authority.
- Only attempt to extinguish a pole fire with a pulse spray hose. Adhere to all other safety measures regarding the 8 metre radius voltage gradient exclusion zone and correct insulating apparel.
- Never stand or park vehicles under the wires near a pole top fire. The fire may disconnect a wire allowing it to fall to the ground.
- Prevent the public and other services personnel approaching the hazard.
- Use a spray nozzle for both pole top and ground level fires.
- Maintain the 8 metre exclusion zone to yourself, other emergency service personnel and members of the public.

Figure 50 Extinguishing a Pole Fire

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.8 Other incidents involving electricity

5.8.1 Trees and branches in contact with wires

The following risks and control measures apply.

Risks

- Trees could transfer lethal currents to people at ground level. (Arcing may not be evident).
- A dangerous voltage gradient (including step and touch potential) at the base of the tree may exist.
- Fires may not start until some time after initial contact.
- Extra strain on wires and poles may snap wires or cause poles to collapse.

Control measures

- Do not fell trees that are in contact with wires or may fall near live wires.
- Maintain at least an 8 metre radius voltage gradient exclusion zone around the base of the tree and notify supply authority.

5.8.2 Unauthorised people in substations or on electrical structures

WARNING

Substations are normally designed to allow safe movement at ground level. They are not designed to ensure safe distances to live equipment when aloft, within cubicles or enclosures or when people are carrying conductive objects. Therefore, risks for people aloft are significantly higher than at ground level.

Most high voltage conductors within substations are uninsulated.

It is not possible for an untrained person to determine visually which part of a substation is likely to be electrically hazardous.

The following risks and control measures apply.

Risks

- Contact with live electrical wires/apparatus can injure or kill.
- Equipment in contact with wire may be live and can injure or kill.
- It is impossible to positively identify if a conductor or equipment is alive or de-energised by its appearance.
- Equipment can become live at any time by remote switching.
- A dangerous ground voltage gradient may exist.
- Covering on wires cannot be considered effective insulation.

Control measures

- Advise people in the substation that they are at extreme danger of being electrocuted and must follow your instructions.
- For people at ground level, instruct them to drop any objects they are holding and, if it can be done without climbing, go to the fence line and stay there. Otherwise, instruct the people to sit down where they are, minimise body movement and remain calm.
- For people aloft, instruct them to remain where they are.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

- Notify the electricity supply authority.
- Trained personnel from the responsible supply authority will isolate and render the area safe.

5.8.3 Debris on structures or wires

The following risks and control measures apply.

Risks

- Debris may cause wires to 'snap' or pole/structure to collapse.
- Debris on live wires may contact the ground and create a dangerous ground voltage gradient.

Control measures

- Establish an initial 8 metre radius voltage gradient exclusion zone.
- If necessary, increase the size of the exclusion zone given that the debris, wires or structure may fail or fall to ground.
- Keep bystanders out of the exclusion zone.

5.8.4 Trains, trams and the Sydney Monorail

Electrified RailCorp network

At incidents on or near the RailCorp network, Incident Controllers must take into account the hazards posed by trains and electric power lines.

Incidents must be managed in consultation with RailCorp staff.

RailCorp Commander

The Communication Centre will notify RailCorp of any call to an incident in the vicinity of the RailCorp network.

RailCorp will send a RailCorp Commander to the incident to liaise with the Incident Controller and ensure that all personnel observe rail safety procedures.

Site safety

Personnel, appliances and equipment must not be allowed on railway lines unless the lines' safety has been verified by the RailCorp Commander.

The Incident Controller must appoint a Safety Officer and should consider posting observers approximately 500m in both directions to warn of approaching trains.

Removing power from overhead lines

To remove the power from overhead lines where there is an immediate risk to life and safety, the Incident Controller must request a Rescue Power Outage in accordance with Operations Bulletin 2009/02, *Removing power from RailCorp overhead power lines*.

⚠ **NOTE**

A Rescue Power Outage is only a *temporary* removal of power from a section of the power network, not a total isolation.

During a major incident such as a derailment or collision, the power to the overhead lines must be isolated as soon as possible by RailCorp engineers.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Sydney Metro Light Rail

An overhead wire that varies between 4.5 m and 5.5 m above the ground supplies 750 volts DC to the cars. The overhead power is supplied by two 1300 kW sub-stations that are each capable of powering the entire system if required. The sub-stations can be remotely controlled and maintained from the Operations Control Centre.

The following risks and control measures apply.

Risks

- Contact with live overhead wire can injure or kill.
- Equipment in contact with the overhead wire may be live and injure or kill.

Control measures

- Notify the owners, Metro Transport Sydney.
- Trained personnel from the transport company will isolate the power and render the area safe.

The Sydney Metro Monorail

Three conductor rails attached to the main monorail track supply 525 volts, 50 Hz AC to the cars.

The following risks and control measures apply.

Risks

- Contact with live conductors on the monorail track can injure or kill.
- Equipment in contact with the live conductors may be live and injure or kill.

Control measures

- Notify the owners, Metro Transport Sydney.
- Trained personnel from the transport company will isolate the power and render the area safe.

5.8.5 Hybrid vehicles

Depending on make and model, hybrid vehicles operate on voltages ranging from about 150 V DC to about 400 V DC. Contact with such a charge could be fatal. The batteries are located in the back of the vehicle under the boot floor and are connected to the motor/generator by large orange cables.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Figure 51 Toyota Prius

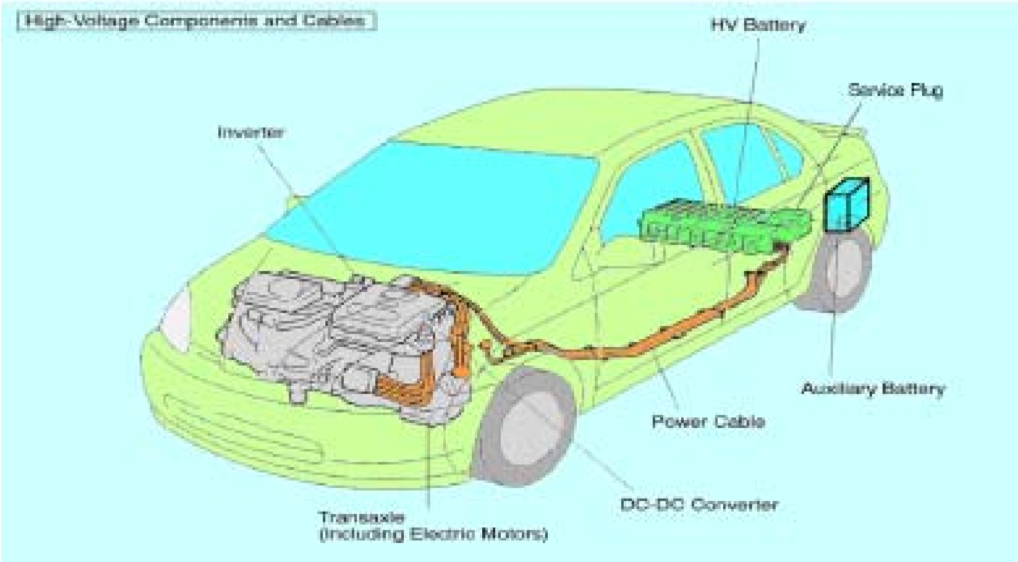
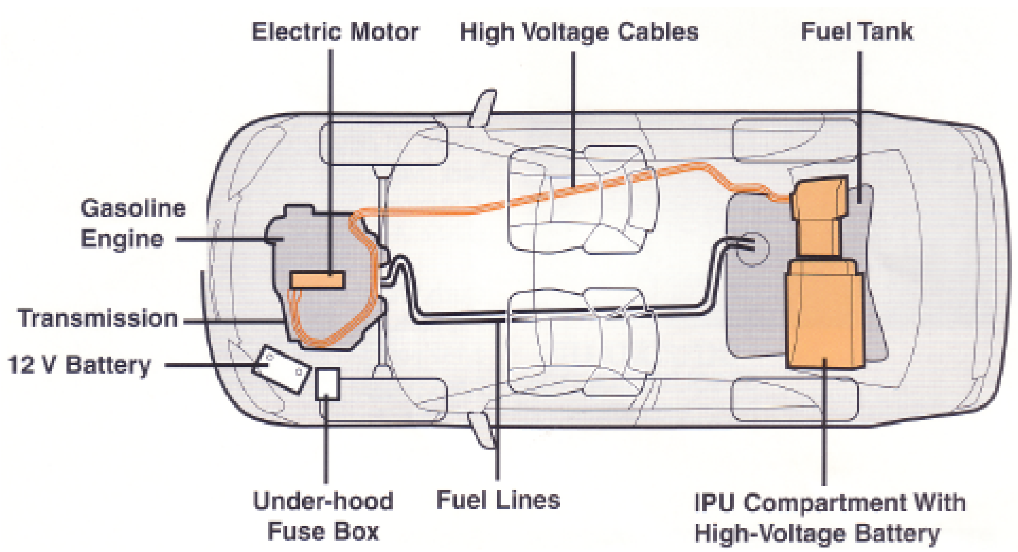


Figure 52 Honda Insight



The following risks and control measures apply.

Risks

- Highly caustic gel (pH 13.5) in high voltage battery can cause severe chemical burns if it comes in contact with body tissue.
- Contact with the large orange power cables can injure or kill if the insulation is damaged.
- Equipment in contact with damaged orange power cables may be live and can injure or kill.

Control measures

As the high voltage battery is made up of a large number of 1.2 V cells about the size of a D-cell, the amount of gel that can leak is limited by the number of cells that are broken. If the NiMH gel leaks, the minimum PPE is a chemical spillage suit and SCBA.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Isolate power from vehicle.

WARNING

Electrical/General purpose gloves and eye protection must be worn while isolating power.

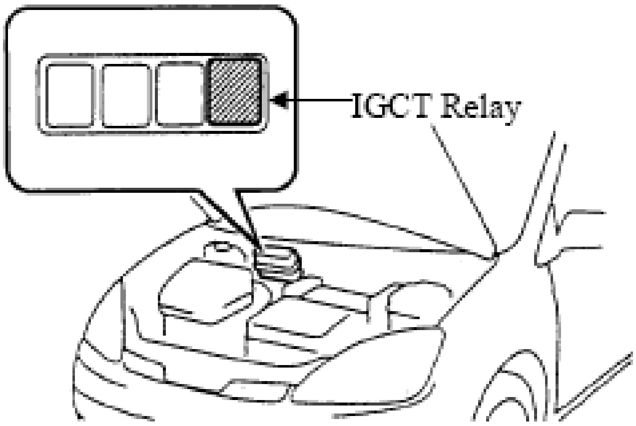
Isolating the Toyota Prius

- Turn off ignition and remove key. If it is an electronic key from a late model Prius, store the key at least 5 metres away from the vehicle.
- Disconnect 12 volt auxiliary battery in the boot.

If unable to remove key from the Toyota Prius:

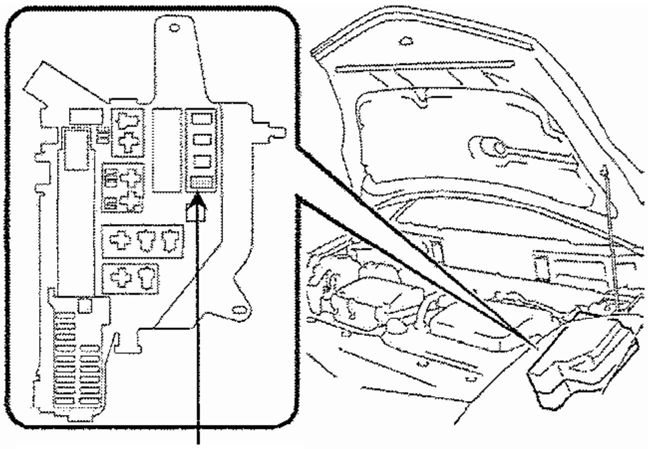
- Disconnect the 12 volt auxiliary battery (earth lead first).
- Remove the IGCT relay in the engine compartment (early models).

Figure 53 IGCT relay



- Remove the HEV fuse (yellow 20 amp) in the engine compartment junction block as illustrated (late models).

Figure 54 Yellow HEV fuse



Yellow HEV fuse

- When in doubt, remove all four fuses from the fuse block.
- Remove the orange service isolation plug found at the rear, left-hand side of the high voltage battery box.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

WARNING

After disabling the vehicle, power is maintained for 90 seconds in the SRS system and 5 minutes in the high voltage electrical system.

If either of the disabling steps above cannot be performed, proceed with caution as there is no assurance that the high voltage electrical system, SRS, or fuel pump is disabled.

Never touch, cut, or open any orange high voltage power cable or high voltage component.

Isolating the Honda Insight

- Turn off the ignition. (Preferred method)
  - * This turns off the engine and electric motor, preventing current flow in the cables. It also turns off power to the airbags and seat belt tensioners.
  - * Remove the key so the car cannot be restarted accidentally.

If unable to remove key from the Honda Insight:

- Remove the main fuse and disconnect the negative cable from the 12 volt battery in the engine compartment. (Second best method)
  - * Removing the main fuse turns off the engine and the electric motor, preventing current flow from the motor to the cables. It also cuts power to the airbags and seat belt tensioners.
  - * Disconnecting the negative cable from the 12 volt battery disables the high voltage battery controller, preventing current flow from the controller to the cables
- Turn off the battery module switch on the Intelligent Power Unit (IPU):
  - * Turning off the battery module switch prevents current flow to the cables. This is the least desirable method because it does not cut power to the airbags and seat belt tensioners. Also, if the engine is running, the high voltage cables could be live.
  - * To turn off the battery module switch, undo the cover plate on top of the high-voltage battery pack, remove the red plastic switch retainer and turn the switch off. Replace the plastic switch retainer to prevent the vehicle from being switched on accidentally.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.8.6 Uninterruptible power supply (UPS)

An uninterruptible power supply (UPS), sometimes called a battery backup, maintains a continuous supply of electric power to connected equipment by supplying power from a separate source when utility power is unavailable.

A UPS is inserted between the source of power (typically, commercial utility power) and the load it is protecting. When a power failure or abnormality occurs, the UPS will effectively switch from utility power to its own power source almost instantaneously.

Power supply to a UPS system from the mains can normally be isolated at the main switchboard. But the UPS is itself a power source, and this does not isolate the power from the UPS to other equipment.

WARNING

Circuits from a UPS system remain live, even after power is isolated at a main switchboard.

Signage similar to that identifying the location of the main switchboard should also identify the location of any UPS system. There may be means of isolating a UPS at that location.

Risks

- Electric shock
- Explosive fumes from charging lead/acid batteries
- Burn risk from acid in batteries

Control measures

- PPE
- SCBA

5.8.7 Backup generators

In some installations, backup generators ensure continuous power for critical operations. In these cases, the backup generator is usually programmed to switch in within seconds of interruption to the regular power supply.

Backup generators can normally be isolated at the main switchboard and should not pose additional risks during firefighting operations.

Risks

- Electric shock

Control measures

- PPE

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

5.8.8 Low clearance to live wires due to sagging wires or floods

The following risks and control measures apply.

Risks

- Structures may be unstable and may collapse causing wires to fall or sag.
- As overhead electrical wires are sometimes difficult to see, extreme care should be taken during emergency work particularly at night or when visibility is otherwise reduced.
- Vehicles may be in contact with wire, e.g. high load.
- Voltage gradient step and touch potentials.
- Extreme heat or an electrical incident may result in conductors sagging to a point where they can be within reach at ground level.

Control measures

- During floods, seek an alternate under-crossing if a clearance of at least 6 metres between highest point of boat and live wires cannot be maintained.
- Travel 6 metres downstream (preferred) or 25 metres upstream of where live overhead electrical cables are low or near to water level.
- Notify the electricity supply authority.
- Maintain an 8 metre radius voltage gradient exclusion zone for NSWFB, other emergency service personnel and members of the public.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Appendix A Resources

A number of documents published by the NSWFB and organisations such as AFAC and publications cover electrical hazards and the management thereof through safe working practices. These documents change over time according to new procedures and knowledge. These documents are all published to the NSWFB Intranet. At the time of writing, these documents include:

- *Firefighters Training Manual* (White Reader).
- Competency Based Training and Assessment (CBT/A) manuals published by the NSWFB, AFAC, TAFE NSW and Hobart TAFE.
- In Orders.
- *Standing Orders.*
- Standard operational guidelines.
- Operations bulletins.
- Safety bulletins.
- Recommended practices.
- *Pre Incident Planning Process, The Pre Incident Plan (PIP) Process,* and *Pre Incident Planning (PIP) Inspection Form.*
- *Dynamic Risk Assessment for Operations: The Safe Person Concept.*
- Risk assessment worksheets.
- *Operational Communications Policy and Procedure: Response and Notification Protocols.*
- Results of the Electrical Hazards Risk Assessment

In addition, the following recruit training programs include material covering electrical hazards and safe working practices:

- Recruit Training.
- Retained Recruit Training.
- Level 1 Firefighter to Qualified Firefighter.
- Station Training Program—Permanent.
- Station Training Program—Retained.
- Senior Firefighters Promotional Program.
- Station Officers Promotional Program.
- Inspectors Promotional Program.
- Driver Training.
- Aerial Training.

NOTE

All NSWFB personnel must ensure that they are aware of current information relating to electrical hazards.

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

Index

abbreviations 2
AC 2
alive 2
alternating current 2
amplifier 6
AOp 2
apartment block distribution board 42
apparatus 4
area operator 2
attachment
  point of 5
authorised person 2
automatic fire extinguishing systems 50
backup generators 62
  control measures 62
  risks 62
basic electrical facts 7
bibliography 1
board
  switch 5
box
  meter 4
  pillar 21
building fires 40
bulk supply point .... 2, 14, *See* Figure 7
  risks 15
  security 15
burn
  electrical .... 9, *See* Figure 1
cable 2, 4
  co-axial 6
  fibre optic 6
  lead-in 6
carbon dioxide 49
casualty in contact with live wire 44
CCA 2, 53, 55
centre
  distribution 12
chlorine 49
Cl 49
clearance to enter 49
CO_2 .... 28, 49, 50, 51, 52
co-axial cable 6
conductive materials
  dangers of 28
conductor 2, 4
  covered 26
conductors 22, 44
control measures
  backup generators 62
  debris on structures or wires 57
  domestic isolation 43
  fire fighting near high voltage powerlines 53
  fires and explosions in underground vaults and tunnels 52
  hybrid vehicles 59
  low clearance to live wires 63
  pole fires 55
  Sydney Metro Light Rail 58
  Sydney Metro Monorail 58
  trees and branches in contact with fallen wires 56
  unauthorised people in substations or on electrical structures 56
  uninterruptible power supply 62
  UPS 62
copper chrome arsenate 2
covered conductors 26
critical incidents 39
current
  direct 2
current, alternating 2
damaged support structures and wires under tension 45
dangers of conductive materials 28
DC 2
debris on structures or wires 57
  control measures 57
  risks 57
de-energised 2
Delta Electricity 12
direct current 2
distribution centre 12
domestic isolation procedure
  240/415 v switchboards 40
domestic switchboard .... *See* Figure 39, *See* Figure 38
earth 2
earthed 2
earthing 2
effect of electrical current on the body .... *See* Figure 2
effect of electricity on the body 8
electric shock 9
  danger of 8
  high voltage 10
electrical burn .... 9, *See* Figure 1
electrical emergencies
  typical 8
electrical hazards 31
electrical network incidents 49
electrical network infrastructure 12
electrical safe working practices 43
electrical safety kit 33
electrical sources 8
electrical station 3
electrical substation fires 49
electrical workers' gloves .... *See* Figure 30
  cleaning and maintaining 34
electricity basics 7

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

electricity distribution .... *See* Figure 3
electricity distributor's direction 49
electricity supply systems 12
electricity terminology 7
electrocution 3
emergency first aid 9
enclosed substation .... 17, *See* Figure 8
construction 17
risks 18
security 18
entry to substations 49
Eraring Energy 12
exposed 3
extra low voltage 3
fallen wires 47
control measures 47
risks 47
fibre optic cable 6
fibrillation
ventricular 9
fire fighting near high voltage powerlines 53
control measures 53
risks 53
fire hazard 39
fire suppression system
city zone substation 50
distribution substation, underground 51
distribution substation—city basement 51
fire suppression systems 50
fires
building 40
fires and explosions in underground vaults and tunnels 52
control measures 52
risks 52
first aid
emergency 9
fuse 4
gas
toxic ... 2, 15, 16, 18, 19, 21, 32, 48, 49, 50, 52, 53, 55
general hazards 32
control measures 32
risks 32
general purpose gloves over electrical gloves 34
generating station 3
generator 4
ground gradient effect .... 35, *See* Figure 33
H_2 49
H_2SO_4 49
hazard
electrical 31
fire 39
general 32
oil 49
Hazardous Materials Response Unit 3
hazmat 3
hierarchy of controls 31
high voltage 3, 7, 15, 16, 18, 19, 21, 23, 56
high voltage and low voltage 7
high voltage cables and insulators .... *See* Figure 18
high voltage electric shock 10
high voltage insulator recognition diagram . See Figure 20
high voltage overhead mains 8
high voltage power lines
fire fighting near 53
HMRU 3
Honda Insight .... 61, *See* Figure 52
HV 3
hybrid vehicles 58
control measures 59
risks 59
hydrogen 49
IC 3
incident controller 3
indoor substation 12
infrastructure
electrical network 12
insulators 22
insulators and conductors 22
introduction 1
isolate 3
isolated 3
kiosk .... 3, 12, 18, *See* Figure 13, *See* Figure 12
construction 19
risks 19
security 19
vehicle in contact with 48
kV 3
lead-in cable 6
line
overhead 4
link 4
live 2
low clearance to live wires
control measures 63
risks 63
low clearance to live wires due to sagging wires or floods 63
low voltage 3, 7, 15, 18, 19, 21, 23
low voltage overhead mains 8
Macquarie Generation 12
mains 4
mains and apparatus 4
meter box 4
minimum safe working distances 4
Modiewark GLM Mini Rescue .... 35, *See* figure 32
N_2 49
nature of electricity 8
network 4
electrical incidents 49

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

nitrogen 49
OH 4
oil hazard 49
operator 4
Optus Communications 6
Optus Vision 6
other incidents involving electricity 56
outdoor enclosure substation 12
overhead 4
overhead line 4
people in contact with live wires or equipment 47
 control measures 47
 risks 47
people trapped in vehicles by fallen wire 47
 control measures 48
 risks 47
person
 authorised 2
personal protective equipment 5, 33
pillar box 21
 construction 22
 risks 22
 security 22
POA 5
pole
 sub-transmission .... 14, *See* Figure 6
pole damage
 control measures 46
 risks 46
 storm .... *See* Figure 44
pole fires 55
 control measures 55
Pole fires
 risks 55
pole substation .... 20, *See* Figure 15, *See* Figure 14
 construction 20
 risks 21
 security 21
pole top recloser .... 29, *See* Figure 28
pole transformer substation 12
polyethylene
 cross linked 5
polyvinyl chloride 5
post insulators .... *See* Figure 19
power station 2, 13
power supply 6
 uninterruptible 5
PPE 5, 33, 52, 59, 62
prescribed burning near energised cables 54
pressure vessel 49
protection system 29
purpose 1
PVC 5
RailCorp network 57
reclose feature 29
recloser
 pole top 29
 zone substation 29
references 1
risk asssessment 31
risks
 backup generators 62
 bulk supply points 15
 debris on structures or wires 57
 domestic isolation 43
 enclosed substations 18
 fallen wires 47
 fire fighting near high voltage powerlines 53
 fires and explosions in underground vaults and tunnels 52
 general 32
 hybrid vehicles 59
 kiosks 19
 low clearance to live wires 63
 people trapped in vehicles by fallen wire 47
 pillar box 22
 pole damage 46
 pole fires 55
 pole substations 21
 Sydney Metro Light Rail 58
 Sydney Metro Monorail 58
 trees and branches in contact with fallen wires 56
 unauthorised people in substations or on electrical structures 56
 uninterruptible power supply 62
 UPS 62
 vehicles in contact with electricity kiosks 48
 zone substation 16
safe working distance
 minimum 4
safe working distances 44
safe working practices
 electrical 43
SCBA 5
scope 2
self contained breathing apparatus 5
SF_6 .... 32, 49
shock 5
 electric 9
solar power panels 8
station
 electrical 3
 generating 3
 power 2, 13
 switching 2
step and touch potential 36
step potential .... 36, *See* Figure 34
strand 6
substation 2
 automatic fire extinguishing 50
 city zone, fire suppression 50
 clearance to enter 49
 control measures 50
 distribution, city basement, fire suppression 51
 distribution, underground, fire suppression 51
 enclosed 17

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009

entry to 49
fires 49
indoor 12
oil hazard 49
outdoor enclosed 12
pole 20
pole transformer 12
pressure vessel 49
toxic gas 50
underground 12
zone 12, 15
zone, enclosed 15
zone, open 16
sub-transmission pole 14, *See* Figure 6
sulphur hexafluoride 32, 49
sulphuric acid 49
supply point
bulk 2, 14, *See* Figure 7
bulk, construction 15
bulk, security 15
supply systems
electrical 12
supply, power 6
support structure
damaged 45
SWER 5
switch board 5
switchboard
domestic *See* Figure 39, *See* Figure 38
unit 42
switchgear 4
switching station 2
Sydney Metro Light Rail 58
control measures 58
risks 58
Sydney Metro Monorail 58
control measures 58
risks 58
tap 6
telco 6
Telstra 6
terms 2
terms and abbreviations 2
touch potential 37, *See* Figure 35
tower
transmission 13
toxic gases 2, 15, 16, 18, 19, 21, 32, 48, 49, 50, 52, 53, 55
Toyota Prius 60, *See* Figure 51
trains, trams and the Sydney Monorail 57
Transdgrid 15
transformer 4
transmission tower 13
construction 53
trees and branches in contact with fallen wires
control measures 56
risks 56
trees and branches in contact with wires 56
UG 5
UGOH 5
unauthorised people in substations or on electrical structures 56
control measures 56
risks 56
underground 5
underground substation 12
underground vaults and tunnels
fires and explosions 52
uninterruptible power supply 5, 8, 62
control measures 62
risks 62
UPS 5, 8, 62
control measures 62
risks 62
vehicles in contact with electricity kiosks 48
control measures 48
risks 48
ventricular fibrillation 9
voltage 5
extra low 3
high 7
low 3, 7
voltage gradient 35
wire 2
XLPE 5
zone substation 12, 15
construction 16
open 16
risks 16
security 16
zone substation recloser 29

COPYRIGHT: © STATE GOVT OF NSW (NSWFB) 2009