OFFICIAL

UEEEL0039 Resource Book

For Revision and Study for Capstone Knowledge Assessments

Workplace Health & Safety (WHS)

In any workplace there are risks and hazards to be considered. As workplaces vary, so will the safety issues and required procedures.

You are responsible for your own safety in any workplace, and you should never rely on others to keep you safe. Always undertake your own risk assessment, identify any hazards and take action to minimise them. The workplace health and safety training that you have done is a vital part of your daily work practices. Correct application of WHS principles ensures your safety and the safety of others in the workplace.

Work activities that involve manual handling, the use of manual hand and power tools, operations on construction and production sites or in public areas will produce multiple risks and hazards for any personnel.

In this unit, you will be required to enter a workplace environment and it is your responsibility to apply safe working practices.

In order to use any tool in a safe manner, you must be familiar with its correct use. Never attempt to use any tool for the first time without becoming familiar with its operation and any safety precautions to be taken during its use.

Information regarding the safe operation of tools or equipment can be found in supplied instructional material, instruction from a competent person, on line or a combination of these. It is not expected that anyone should know how to operate every tool or piece of equipment they come across in the industry.

Asking for operational instruction, PPE requirements and safety issues for any tool/equipment that is unfamiliar to you is an essential part of your work preparation.

Injuries and fatalities have resulted from the misuse of tools and equipment in the workplace, make sure that you are prepared as well as you can be to undertake any new work practice or assessment.

Remember, if you don’t know, ask.

Supplementary Content

Definitions

Definitions	
Arc fault detection device (AFDD)	A circuit breaker that automatically cuts the electricity supply when it detects an arc fault in a circuit. By cutting the electricity supply, AFDD's help prevent arc faults from reaching temperatures where electrical fires can break out.
Asbestosis	Severe scarring of lung tissue. Pleural plaque is a benign growth in the pleural membranes surrounding the lungs that produces patches of thickening in those membranes.
Average value	The average of all the instantaneous values for one-half of a cycle
Block diagram	Where blocks are drawn (square or rectangular) to symbolize a component and labelled to indicate its purpose.
Circuit breaker (C/B) or Miniature circuit breaker (MCB)	AS/NZS 3000, Clause 1.4.30
Circuit diagram	Uses single lines and circuit symbols to show the sequence of operation of the circuit.
Clearance	The "line of sight" distance or the shortest air path between two conductors. The shortest distance that can achieve insulated through the air.
Closed circuit	An electrical circuit that is complete, with good continuity throughout. The switch is in the 'ON" position.
Commissioning	Commissioning is a systematic process of verifying the performance of facilities, systems, and assemblies to ensure trouble-free outcomes and mitigate the risk of unplanned outages or downtime.
Creepage	The shortest distance between two conductors along the insulating surface. Creepage must be greater than or equal to clearance.
Decommissioning	Decommissioning is the process of shutting down a building and/or removing it from operation or use. Common types of buildings that may be decommissioned include power stations, oil rigs, factories, warehouses, public buildings and so on.
Earth	AS/NZS 3000, Clause 1.4.47
Earthed situation	AS/NZS 3000, Clause 1.4.48
Earthing conductor	Main earth - AS/NZS 3000, Clause 1.4.81
	Protective earth - AS/NZS 3000, Clause 1.4.100
Electrocution	The level of current, its duration and the path it takes through the body
Equipotential bonding	AS/NZS 3000, Clause 1.4.60
Fault current	AS/NZS 3000, Clause 1.4.41
Fault protection	AS/NZS 3000, Clause 1.4.98
Frequency	Number of whole cycles completed in one second
Fuse	AS/NZS 3000, Clause 1.4.68
Fuse – High Rupturing Capacity (HRC)	Interrupt's high fault currents without damage to itself
Hazard	A Work practice or procedure that has the potential to cause harm or injury.
Hazardous area	A hazardous area is where an explosive atmosphere is or may be expected to be present or form.
Incorrect circuit connections	Transposition of active and neutral conductors of consumer mains and incorrect active, neutral and earthing conductor connections.
Induced voltage	A voltage produced in a circuit from a nearby electric field.
Instantaneous value	Varies from zero to a peak value many times per second

Definitions	
Insulation Failure	A condition where the insulation of a material or a device fails to prevent the flow of electric current or heat. It can cause fires, high fault currents, overheating.
Line diagram	A representation of a complicated electrical distribution system into a simplified description using a single line, which represents the conductors, to connect the components.
Job Safety Analysis (JSA)	Completed before a specific job or task is carried out.
Ladder diagram	Resemble a ladder, two vertical lines, line and neutral, and a number of horizontal lines for the control circuits.
Maximum value	The highest value the wave reaches at 90° and 270°
Mesothelioma	Cancer of the lining of the lungs, caused by inhaling asbestos fibres over a period of time
Open circuit	An electrical circuit where the continuity is broken so that current cannot flow. A circuit that is not complete/closed. The switch is in the 'OFF' position.
Overcurrent	A current exceeding the rated value. (Clause 1.4.90)
Overload Current	An overcurrent occurring in a circuit that is electrically sound.
Peak-to-Peak value	The vertical distance between the top and bottom of a waveform
Period	The time duration of one cycle
Physiological effect of current	An electric current passing through a material which has the ability to burn living tissue well beneath the skin of a victim, even burning internal organs. The amount of current, its duration and the path it takes through a human body will determine if a person lives.
Protected extra-low voltage (PELV)	AS/NZS 3000, Clause 1.4.96
Risk	The chance or probability that a person will be harmed if exposed to a hazard.
Risk assessment	A term used to identify hazards and risk factors that have the potential to cause harm (hazard identification). Requires analysing and evaluating the risk associated with that hazard (risk analysis, and risk evaluation). A worker completes a Risk Assessment Checklist (RAC).
Residual Current Device (RCD)	AS/NZS 3000, Clause 1.4.102
Residual Current Breaker with Over-Current (RCBO)	Protects against two types of faults and in essence combines the functionality of an MCB and RCD.
Root-Mean-Square (r.m.s) value	Relates an a.c. value to an equivalent d.c. value
Safety Data Sheet (SDS)	A detailed informational document prepared by the manufacturer or importer of a hazardous chemical. It describes the physical and chemical properties of the product. It determines whether a substance is hazardous based on its health effects.
Safe Work Method Statement (SWMS)	Specifically for High-Risk Construction Work (HRCW).
Separated extra-low voltage (SELV)	AS/NZS 3000, Clause 1.4.105
Short-circuit Current	AS/NZS 3000, Clause 1.4.43
Step voltage/potential	The voltage between the feet i.e. one step of a person standing near an energised grounded object.
Touch voltage	The touch voltage between the energised object and the feet of a person in contact with the object - AS/NZS 1.4.125

Definitions	
Unsafe condition	The existence of an electrical, mechanical, chemical, environmental condition or situation which may cause a hazard or accident. Examples are: Loose electrical connections, damage to insulation, frayed/damaged cords.
Wiring diagram	A detailed diagram of a circuit showing the conductors and where they connect.

Activity 1

Work Health and Safety Act 2020

Part 1 — Preliminary

Division 1 — Introduction

1. Short title

This is the Work Health and Safety Act 2020.

2. Commencement

(1) This Act comes into operation as follows —

(a) Part 1, other than Divisions 2 to 5 — on the day on which this Act receives the Royal Assent (assent day).

(b) Part 14, other than Divisions 1 to 3 — on the day after assent day.

(c) the rest of the Act — on a day fixed by proclamation.

(2) However, if no day is fixed under subsection (1)(c) before the end of the period of 10 years beginning on assent day, this Act is repealed on the day after that period ends.

Division 2 — Object

3. Object

(1) The main object of this Act is to provide for a balanced and nationally consistent framework to secure the health and safety of workers and workplaces by -

(a) protecting workers and other persons against harm to their health, safety and welfare through the elimination or minimisation of risks arising from work; and

(b) providing for fair and effective workplace representation, consultation, cooperation and issue

resolution in relation to work health and safety; and

(c) fostering cooperation and consultation between, and providing for the participation of, the following persons in the formulation and implementation of work health and safety standards to current levels of technical knowledge and development and encouraging those persons to take a constructive role in promoting improvements in work health and safety practices —

(i) workers;

(ii) persons conducting businesses or undertakings;

(iii) unions;

(iv) employer organisations; and

(d) promoting the provision of advice, information, education and training in relation to work health and safety; and

(e) securing compliance with this Act through effective and appropriate compliance and enforcement measures; and

(f) ensuring appropriate scrutiny and review of actions taken by persons exercising powers and performing functions under this Act; and

(g) providing a framework for continuous improvement and progressively higher standards of work health and safety; and

(h) providing for the formulation of policies, and for the coordination of the administration of laws, relating to work health and safety; and

(i) maintaining and strengthening the national harmonisation of laws relating to work health and safety and to facilitate a consistent national approach to work health and safety in the State.

(2) In furthering subsection (1)(a), regard must be had to the principle that workers and other persons should be given the highest level of protection against harm to their health, safety and welfare from hazards and risks arising from work as is reasonably practicable.

Notes for this section:

1. This Act is based on the Model Work Health and Safety Bill (21 March 2016 version) prepared for, and approved by, the Council of Australian Governments and contains modifications of that model Bill for this State.

2. The numbering of Parts, Divisions and sections in this Act generally (but not always) corresponds to the numbering of Parts, Divisions and sections in the model Bill.

To facilitate this correspondence —

(a) some Part, Division and section numbers are included in this Act although they are not used for this State; and

(b) alphanumeric numbers are used in this Act for some sections that are inserted for this State.

3. Alphanumeric numbering used in the model Bill is also used in this Act.

2.1 Identify the hazards

Identifying hazards involves finding all of the tasks, situations and sequences of events that could potentially cause harm.

Hazards arising from electrical equipment or installations may arise from:

- the design, construction, installation, maintenance and testing of electrical equipment or electrical installations
- design change or modification
- inadequate or inactive electrical protection
- where and how electrical equipment is used. Electrical equipment may be subject to operating conditions that are likely to result in damage to the equipment or a reduction in its expected life span. For example, equipment may be at greater risk of damage if used outdoors or in a factory or workshop environment
- electrical equipment being used in an area in which the atmosphere presents a risk to health and safety from fire or explosion, for example confined spaces
- type of electrical equipment. For example, 'plug in' electrical equipment that may be moved around from site to site, including extension leads, are particularly liable to damage
- the age of electrical equipment and electrical installations
- work carried out on or near electrical equipment or electrical installations, including electric overhead lines or underground electric services, for example work carried out in a confined space connected to plant or services.

Exposure to high electromagnetic fields may also present a potential hazard for workers with some medical conditions, for example pacemakers. You must inform workers and other persons at the workplace of any potential electromagnetic hazards at the workplace that may affect a medical condition. You must also manage risks to health and safety arising out of electromagnetic hazards, including eliminating the risk as far as is reasonably practicable. If that is not reasonably practicable you must minimise the risk/s as far as is reasonably practicable.

Potential electrical hazards may be identified in a number of different ways including:

- talking to workers and observing where and how electrical equipment is used
- regularly inspecting and testing electrical equipment and electrical installations as appropriate
- reading product labels and manufacturers' instruction manuals
- talking to manufacturers, suppliers, industry associations, and health and safety specialists
- reviewing incident reports.

2.2 Assess the risks

Risk assessment involves considering what could happen if someone is exposed to a hazard (consequence) and the likelihood of it happening.

For work on energised electrical equipment, the WHS Regulations require that a risk assessment be prepared in writing by a competent person; for more information see Part B of this Code.

A risk assessment can help determine:

- the severity of an electrical risk
- whether existing control measures are effective
- what action you should take to control an electrical risk
- how urgently the action needs to be taken.

To assess the risk associated with electrical hazards consider:

- What is the potential impact of the hazard?
- How severe could the electrical hazard be? For example, direct contact causing
- electrocution, fire, or explosion causing serious burns or death.
- How many people are exposed to the hazard?
- How likely is the hazard to cause harm?
- Could it happen at any time, or would it be a rare event?
- How frequently are workers exposed to the hazard?

Other factors that may affect consequence and likelihood include:

- the conditions under which the electrical equipment is used, for example wet conditions
- outdoors or confined spaces
- work practices and procedures, for example isolation, to carry out maintenance
- the capability, skill and experience of relevant workers.

2.3 Control the risks

Once hazards have been identified and the risks assessed, appropriate control measures must be put in place.

The ways of controlling risks are ranked from the highest level of protection and reliability to the lowest.

This ranking is known as the hierarchy of risk control. You must work through this hierarchy to choose the control that most effectively eliminates or minimises the risk in the circumstances, as far as is reasonably practicable. This may involve a single control measure or a combination of two or more different controls.

Elimination

The most effective control measure is to remove the hazard or hazardous work practice.

By designing-in or designing-out certain features, hazards may be eliminated.

Substitution

Replacing a hazardous process or material with one that is less hazardous will reduce the hazard, and hence the risk. For example, it may be reasonably practicable to use extra low voltage electrical equipment such as a battery-operated tool rather than a tool that is plugged into mains electricity.

Isolation

Preventing workers from coming into contact with the source of an electrical hazard will reduce the relevant risks.

Engineering controls

Use engineering control measures to minimise the risk, for example installing residual current devices to reduce the risk of receiving a fatal electric shock.

Administrative controls

Administrative controls involve the use of safe work practices to control the risk, for example establishing exclusion zones, use of permits and warning signs.

Personal Protective Equipment (PPE)

PPE includes protective eyewear, insulated gloves, hard hats, aprons and breathing protection. Most forms of PPE are not relevant to minimising electrical risks in workplaces, except in relation to energised electrical work.

Administrative controls and PPE do nothing to change the hazard itself. They rely on people behaving as expected and require a high level of supervision. Exclusive reliance on administrative controls and PPE must only occur where other measures are not reasonably practicable or as an interim control while the preferred control measure is being implemented.

You should check that your chosen control measure does not introduce new hazards.

The Difference Between a JSA and SWMS

JSA and SWMS - What you need to know

What is a JSA?

A Job Safety Analysis (JSA) (sometimes referred to as a Job Hazard Analysis, or JHA) is a form of risk assessment that's required to be completed for general construction tasks and is completed before a task is carried out.

A JSA is a written procedure developed to review work steps and their associated hazards in order to put in place correct solutions to eliminate or minimise the risk of those hazards.

JSA's are commonly used in construction and other heavy industries, where there are hundreds of inherent dangers and hazards associated with doing normal work.

Note: The JSA can also be completed as part of preparing a Safe Work Method Statement which is a written procedure for the high-risk construction work.

How is a job safety analysis (JSA) developed? (dmp.wa.gov.au)

Sometimes the JSA is called a JSEA and includes environmental aspects as well.

The components of a JSA may include:

1. Cover page, where the details of the business, worker, work activity, PPE etc. is recorded.
2. Risk rating matrix – the levels will be different between companies however the same outcome, going from a high risk to a low risk, will be accomplished.
3. Risk controls – definition and list of controls e.g. eliminate, isolate, PPE
4. Action sheet:
   - Tasks- A step-by-step list of the basic activities of the task e.g. disconnecting electrical equipment.
   - Hazards – List of potential hazards at each step of the task.
   - Control Measures - Step-by-step instruction on how to safely carry out the task by controlling each identified hazard.

Identifying potential hazards?

Examples of questions to ask to help identify potential hazards.
Note: this list is just some of the questions to ask.

- Can body parts get caught in or between objects?
- Do tools, machines, or equipment present any hazards?
- Can a worker come into any harmful contacts with moving objects?
- Can a worker slip, trip, or fall?
- Can a worker suffer strain from lifting, pushing, or pulling?
- Is a worker exposed to extreme heat or cold?
- Is a work exposed to excessive noise or vibration/s?
- Is there a danger from falling objects?
- Is lighting a problem?
- Can environmental conditions, such as weather, affect safety?
- Is harmful radiation a possibility?
- Is it a chemical hazard? (Read information on a Safety Data Sheet below)
- Can contact be made with hot, toxic, or caustic substances?
- Are there dusts, fumes, mists, or vapors in the air?

Safety Data Sheet (SDS)
A SDS is a detailed document prepared by the manufacturer or importer of a hazardous chemical. It describes the physical and chemical properties of the product.

It determines whether a substance is hazardous based on its health effects.

What is a SWMS?

A Safe Work Method Statement(s) (SWMS) demonstrates how hazards are identified and risks are assessed. The procedures should cover WHS hazards and risks relevant to the work activities. The difference between a JSA and a SWMS is that SWMS are prescribed for all High-Risk Construction Work (HRCW), on a construction site, under safety regulations in Australia.

https://www.commerce.wa.gov.au/publications/safe-work-method-statements

SWMS must be in writing and, as far as practicable, set out:

- each high-risk construction work activity that is or includes a hazard.
- the risk of injury or harm to a person resulting from any such hazards.
- the safety measures to be implemented to reduce the risk, including the control measures which are genuinely based on the hierarchy of controls.
- a description of the equipment to be used in the work activity.
- the qualifications and training (if any) required for persons doing the work.

Note: In Western Australia, SWMS must also include training and equipment.

Additional Duties for SWMS in Construction:

- Employer must ensure the SWMS is complied with.
- If the task or conditions change, the work must immediately 'STOP' and the SWMS reviewed and updated.
- SMWS is kept for the duration of the task and a SWMS must also be given to the Principal Contractor prior to work commencing.
- Unnecessary details can distract from the primary purpose of the SWMS i.e. to identify and control the hazards.

Examples where a SWMS is required for the high-risk construction work activities:

- Risk of a person falling more than 2 metres
- Work in or near an excavation deeper than 1.5m
- Work around mobile plant
- Structural alterations or repairs that need temporary support
- Disturbance of asbestos
- Work on telecommunication towers
- Demolition of a load-bearing structure
- Work in or near a confined space (no free flow of air)
- Use of explosives (not including explosive power tools)
- Work in or near pressurised gas mains or piping
- Work on or near chemical, fuel or refrigerant lines
- Work on or near energised electrical installations
- Work in an area that may have a contaminated or flammable atmosphere
- Tilt-up or pre-cast concrete elements
- Adjacent to a road or other traffic/transport corridor
- Work in areas with artificial extremes of temperatures
- In or near water or liquid
- Diving work

Asbestos

Asbestos is a naturally occurring silicate mineral fibre that is strong, heat resistant and has good electrical insulation properties. It consists of long thin silicate crystals with each fibre being composed of numerous microscopic fibrils that easily leave the material when disturbed and become airborne.

Asbestos exists naturally in several forms with white, brown and blue being common types. Due to its various physical properties, asbestos gained wide industrial use in the 19th and 20th century and is still used in many countries today.

Asbestos products are derived from two mineral families:

- Amphibole asbestos types typically have sharp, straight chain like structures.
- Serpentine (chrysotile or white asbestos) type has a curly layered fibrous structure.

Many building materials like asbestos fibre cement panelling, fire resistant coatings and electrical insulating materials as well as automotive brake and exhaust systems have all used asbestos at some time. It has been used in fabrics, pipes and thermal insulation products.

The adverse effect of asbestos on human health was suspected in the early 20th century and its use was steadily phased out from the 1970's with mining ceasing in 1983. Asbestos products were phased out in the late 1980's and banned entirely in Australia in December 2003.

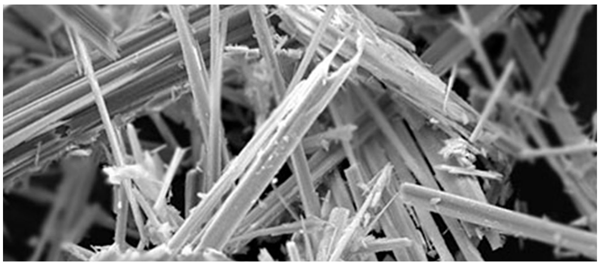
Asbestos products are found in many buildings that were constructed before Australia banned the product and due to other countries not banning asbestos, imported materials are sometimes found to contain the substance.

Dangers of Asbestos

When asbestos fibres are mechanically disturbed, they become airborne and can enter the repertory system. Individual fibres are so light that they can stay suspended in still air for up to 72 hrs. Air currents can keep fibres aloft for much greater time periods. All forms of asbestos are dangerous when inhaled or ingested. Friable material crumbles into a powder easily when dry becoming airborne readily. Asbestos cement products are referred to as non-friable as the fibres are suspended in hardened cement. With aging, surface fibres on these products become loose and easily disturbed on contact.

When asbestos fibres are inhaled, they can cause serious diseases such as Mesothelioma (cancer of the lining of the lungs), Asbestosis (severe scarring of lung tissue) and Asbestos- related lung cancer. Pleural plaque is a benign growth in the pleural membranes surrounding the lungs that produces patches of thickening in those membranes.

In many cases, it will take decades for the symptoms of asbestos diseases to present and there is currently no cure for Mesothelioma or Asbestosis. Globally, approximately 90,000 people a year die from asbestos related disease.



Amphibole Asbestos

Asbestos cement corrugated sheeting

Identifying Asbestos

Unfortunately, there is no easy way to identify products containing asbestos as the fibrous material is small and similar to other mineral fibres. The only wat to be sure is to have a sample taken and sent to a laboratory for identification. Any worker who discovers what they think may be friable asbestos containing material in their work area should report the find to their employer immediately. Only competent people trained in handling asbestos should take samples.

It is fair to say that workers are likely to encounter asbestos products in structures built before the mid 1980's and all suspect products should be treated as asbestos until confirmed otherwise.

Whenever it is determined that asbestos products could be on a site, suitable warning signage is to be placed. For removal of asbestos, danger signage must be placed during operations. A variety of danger and caution signage is displayed below.

Electrical switchboard panels installed prior to 2004 may contain asbestos. Old switchgear fuses and wiring systems can also contain asbestos products. Workers need to be aware of the possibility of exposure to asbestos when working on switchboard panels and what steps to take to minimise any hazard.

The National Occupational health and Safety Commission has produced a code of practice for the management and control of asbestos in workplaces and it is the responsibility of the PCBU (Person conducting a business undertaking) to train staff accordingly under the WHS Act if they are likely to encounter asbestos in the work environment.

When working in an environment where asbestos may be present, every individual must wear appropriate PPE to minimise the possibility of exposure to fibres. Removal of large amounts of asbestos from contaminated sites must be undertaken by licensed professional companies with suitably trained employees. Any non-friable sheet asbestos area greater than $10m^2$ must be removed by a licensed removal company. Only an A class licensed asbestos removal contractor can remove friable material.

Silica

Often referred to as quartz, silicon dioxide (SiO_2) makes up over 50% of the earth's crust and is the major constituent of sand. Sand and rock is used in the building industry to make all types of building products such as concrete, mortar, bricks, paving, manufactured sheeting materials, tiles and natural stone products.

When cutting or drilling these products, silica dust is produced by abrasive action causing a health risk to workers. The inhalation of fine silica dust particles can cause severe inflammation of lung tissue bringing about a variety of diseases such as silicosis, bronchitis, lung cancer and autoimmune diseases. Diseases like silicosis may take 20 to 45 years to develop at moderate exposure levels but long term exposure to high levels of silica dust can bring on the disease much earlier. Using the hierarchy of control, eliminating the hazard of exposure to silica is the only way to ensure protection against the health hazard of silica in the workplace. PPE is always the last option in hazard minimization.

Some anchor systems designed for concrete fixing require holes to be cleaned out with compressed air after drilling to ensure correct installation of the anchor. This will obviously produce airborne silica dust and appropriate precautions must be taken by workers when performing this work.

The use of vacuum extraction and water suppression systems in the workplace will greatly reduce the silica dust hazard associated with the cutting and drilling of building materials. Vacuum dust extraction systems attach to cutting tools and suck dust and particulates away from the cutting area during operation. Water suppression systems introduce water to the cutting area during cutting operations turning dust into a mud solution. This action also cools cutting blades which helps to extend blade life.

As with asbestos, appropriate PPE must be worn when working in areas where silica dust is present.

Safe Work Australia states that the workplace exposure standard for respirable crystalline silica cannot exceed 0.05 mg/m3 averaged over an eight hour period. Control measures must be put in place when levels exceed these values. Air monitoring must be undertaken on a site if exposure levels are not known.

Dust

Any dusty environment is a potential hazard to personnel as foreign material entering the lungs can cause new or aggravate existing respiratory conditions. Grain dust, saw dust, plaster dust, spray paint particulates, pollen and smoke can all cause respiratory conditions and individuals need to take appropriate precautions when exposed to these substances. Dust can also get into the eyes causing irritation and damage so protective eyewear must be used in dusty situations.

Irritation from dust (including silica) brings on coughing and the production of phlegm which is the body's natural way of removing foreign material from the lungs. Fine dust particles can become lodged deep in lung tissue and remain there so prevention with suitable PPE is the best defence when exposed to dust.

Division 2 — Primary Duty of Care

19. Primary Duty Of Care

(1) A person conducting a business or undertaking must ensure, as far as is reasonably practicable, the health and safety of —

(a) workers engaged, or caused to be engaged, by the person; and

(b) workers whose activities in carrying out work are influenced or directed by the person, while the workers are at work in the business or undertaking.

(2) A person conducting a business or undertaking must ensure, as far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.

(3) Without limiting subsections (1) and (2), a person conducting a business or undertaking must ensure, as far as is reasonably practicable —

(a) the provision and maintenance of a work environment without risks to health and safety; and

(b) the provision and maintenance of safe plant and structures; and

(c) the provision and maintenance of safe systems of work; and

(d) the safe use, handling and storage of plant, structures and substances; and

(e) the provision of adequate facilities for the welfare at work of workers in carrying out work for the business or undertaking, including ensuring access to those facilities; and

(f) the provision of any information, training, instruction or supervision that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking; and

(g) that the health of workers and the conditions at the workplace are monitored for the purpose of preventing illness or injury of workers arising from the conduct of the business or undertaking.

(4) If —

(a) a worker occupies accommodation that is owned by or under the management or control of the person conducting the business or undertaking; and

(b) the occupancy is necessary for the purposes of the worker's engagement because other accommodation is not reasonably available, the person conducting the business or undertaking must, as far as is reasonably practicable, maintain the premises so that the worker occupying the premises is not exposed to risks to health and safety.

(5) A self-employed person must ensure, as far as is reasonably practicable, the person's own health and safety while at work.

Note for this subsection:

A self-employed person is also a person conducting a business or undertaking for the purposes of this section.

Note: for this section: Health means physical and psychological health — see section 4.

75. Health and Safety Committees

(1) The person conducting a business or undertaking at a workplace must establish a health and safety committee for the business or undertaking or part of the business or undertaking —

(a) within 2 months after the day on which the person is requested to do so by —

(i) a health and safety representative for a work group of workers carrying out work at that workplace; or

(ii) 5 or more workers at that workplace.

or

(b) if required by the regulations to do so, within the time prescribed by the regulations.

Penalty for this subsection:

(a) for an individual, a fine of $5,500,

(b) for a body corporate, a fine of $30,000.

(2) A person conducting a business or undertaking at a workplace may establish a health and safety committee for the workplace or part of the workplace on the person's own initiative.

Note for this section: If a health and safety committee is not required to be established, other consultation procedures can be established for a workplace — see Division 2 of this Part.

Excerpt from Safe Working Guidelines for Electricians - Section 5

Electrical Isolation and De-Energisation of Equipment

Before commencing any electrical work, the circuits or equipment to be worked on must be disconnected from all sources of electricity supply, the isolation points physically secured to prevent inadvertent re-energisation, and proven to be de-energised.

Principles and safe practices for the effective de-energisation of electrical circuits and equipment are provided in Building and Energy's 'Code of Practice for Persons working on or near energised electrical installations,' AS/NZS 4836.

The key steps are summarised below for reference.

Essential Steps for Effective De-Energisation of Equipment

Equipment is energised

1. Isolate - identify and disconnect all sources of electricity:
    - switch of isolator/circuit breaker, and/or
    - remove fuses or other components.
2. Secure - secure the isolation:
    - lock isolator/circuit breaker in 'OFF' position, and
    - fit danger tag at isolation point.
3. Test - test that equipment is deenergised:
    - check test instrument with known voltage source, then
    - test equipment is de-energised, then
    - re-check test instrument with same voltage source.

Securing the Isolation

Locks

Where a facility exists to lock a switch in the "OFF" position, it must be used. Where a facility does not exist, a portable lock out device ("lock dog") must be fitted to the switch mechanism to prevent closing.

Locks are for the safety of personnel and:

- they must be uniquely keyed so that they can be fitted and removed only by the person owning the lock,
- all persons involved in carrying out the work must fit their own lock at the same isolation point(s). This may require the use of a multi-lock security device,
- they must be clearly labelled (with a personal identification tag or Danger tag) to identify the owner and the nature of the electrical work being undertaken, and
- they must be removed upon completion of work or at the end of the shift (if the work will be continued by others, who must fit their own locks).

Danger Tags

A Danger tag on an item of equipment is a warning to all persons that the equipment must not be operated, as lives may be placed in danger.

Danger tags are for the safety of personnel and:

- they must be attached in a prominent position at each isolation point,
- they must be fitted and removed only by the person who signed the tag,
- all persons involved in carrying out the work must fit their own Danger tag at the same isolation point(s), and
- they must be removed upon completion of the work or at the end of the shift (if the work will be continued by others, who must fit their own Danger tags).

Out of Service Tags

This tag is used to identify appliances or equipment that are out of operation for repairs or alterations or are still in the process of being installed. While an Out of Service tag is fitted, the appliance or equipment must not be operated.

Out of Service tags are for the safety of personnel and security of equipment and must be:

- attached in a prominent position at the point of isolation of the appliance or equipment that is being worked on; and
- fitted and removed only by authorised persons.

Isolation Procedure Example

You have been asked to remove a three phase fan which has its own isolating switch and is on its own final sub circuit, with power being supplied from a circuit breaker at the distribution board.

NOTIFY	Supervisor(s) and any employees that may be affected	
IDENTIFY	Circuit breaker, isolating switch, known live source and motor.	**1**
WORK SAFE	Complete a JSA and set up barricading	
ISOLATE	Circuit breaker and isolating switch.	**2**
LOCK OUT	Circuit breaker and isolating switch.	**3**
TAG	Danger Tag - isolating switch and circuit breaker	**4**
TEST THE TESTER	On a known voltage source, to make sure the tester works correctly.	**5**
TEST	For **ZERO VOLTS** all terminals of the motor, U-E, W-E, V-E, V-W, U-W and W-V.	**6**
TEST THE TESTER	At the known voltage source to make sure the tester still works.	**7**
DISCONNECT	Cables to fan.	
REMOVE	Fan.	
MAKE SAFE	By putting conductors into cable connectors and putting all into a j/box in a safe and tidy manner. Tidy up work area(s).	
CHANGE TAGS	Change **DANGER TAG** to **OUT OF SERVICE TAG** if job is incomplete. Remove lock if one is attached.	
NOTIFY	Supervisor(s) job is completed.	
PACK UP	Tools, equipment and barricading	

Excerpt from Safe Working Guidelines for Electricians – Section 2 - Levels of Supervision for Apprentices

https://www.commerce.wa.gov.au/building-and-energy/safe-working-guidelines-electrical-workers

Levels of Supervision for Apprentices

Three different levels of supervision are defined in detail in Regulation 49D and briefly summarised below:

(1) Direct Supervision

'Direct' supervision applies where the apprentice requires constant guidance and monitoring by the supervising electrical worker to ensure the work task is carried out safely and correctly.

The supervising electrical worker must remain on the same work site as, and in close proximity to, the apprentice.

(2) General Supervision

'General' supervision applies where the apprentice requires periodic guidance and monitoring to ensure the work task is carried out safely and correctly.

The supervising electrical worker must remain on the same work site as the apprentice and be readily available to provide guidance and assistance.

(3) Broad Supervision

'Broad' supervision applies where the apprentice does not require ongoing guidance and monitoring while performing familiar tasks.

The supervising electrical worker does not need to remain on the same site as the apprentice but must, as a minimum, attend the work daily to provide initial instruction and to verify the electrical work has been carried out safely and correctly.

Determining Appropriate Levels of Supervision for Apprentices

The level of guidance required by an apprentice can be expected to diminish gradually over the course of the apprenticeship, as increasing competence is attained and demonstrated by the apprentice.

However, the appropriate level should be applied at any time based on the supervising electrical worker's assessment of the apprentice's competence to perform each task. For example, a task being performed for the first time or in an unfamiliar environment in the final year of training may initially require direct supervision for that particular task.

The following table provides guidance to employers and supervising electrical workers on appropriate minimum levels of supervision of apprentices at different stages of training and for different work types (de-energised only), subject to assessment by the supervising electrical worker.

Type of Work (de-energised only)	Apprentice Training Year	Recommended Minimum Supervision Level
New electrical installations (not connected to electricity supply)	1st	General
	2nd	General
	3rd	Broad
	4th or final	Broad
Maintenance, alterations and additions to existing electrical installations (isolated and proven de-energised by supervising electrical worker)	1st	Direct
	2nd	General
	3rd	General
	4th or final	Broad
Workshop assembly and maintenance of electrical equipment (not connected to electricity supply)	1st	General
	2nd	General
	3rd	Broad
	4th or final	Broad
Tag and lockout procedure on de-energised installations and equipment (isolated and proven de-energised by supervising electrical worker)	1st	Direct
	2nd	General
	3rd	General
	4th or final	Broad
Testing and fault-finding on de-energised installations and equipment (not connected to electricity supply or isolated and proven de-energised by supervising electrical worker)	1st	Direct
	2nd	Direct
	3rd	General
	4th or final	General

The levels of supervision applied in practice may vary from the recommended minimum levels subject to a diligent assessment by the supervising electrical worker of the nature of the work, the specific circumstances and risks, and the competence of the apprentice to perform the task.

Excerpt from:https://www.fireextinguisheronline.com.au/blog/post/types-of-fire-extinguisher-in-australia-all-you-need-to-know

Types of Fire Extinguisher in Australia

The five main types of fire extinguishers are:

1. Water
2. Foam
3. Dry Powder ABE and BE
4. Carbon Dioxide (CO2)
5. Wet Chemical

Note: A Fire blanket and fire hose reel can also be used to extinguish a fire.

It is important to select the correct extinguisher for the type of fire you are extinguishing. If you select the wrong type of extinguisher, it can be ineffective on the fire and also cause harm. Suitable extinguishers must be installed in areas where fire risks such as flammable liquids or electrical fire are present. In other areas, an extinguisher that covers several fire types is usually installed.

Classes of Fire

There are six classes of fire:

- Class A fires - combustible materials: caused by flammable solids, such as wood, paper, and fabric
- Class B fires – flammable liquids: such as petrol, turpentine or paint
- Class C fires – flammable gases: like LPG, hydrogen, butane or methane
- Class D fires – combustible metals: chemicals such as magnesium, aluminium or potassium
- Class E fires – electrical equipment: once the electrical item is removed, the fire changes class
- Class F fires – cooking oils: typically a chip-pan fire

Common Extinguisher types and their applications

- Water, Dry chemical powder ABE, Foam, Wet chemical used on Class A Flammable Materials (paper & wood)
- Dry chemical powder ABE, Foam, Wet chemical used on Class B Flammable Liquids (paint & petrol)
- Dry chemical powder ABE (care should be taken however) used on Class C Flammable Gases (butane & methane)
- Dry chemical powder ABE (care should be taken however) used on Class D Flammable Metals (lithium & potassium)
- Dry chemical powder ABE, Dry chemical powder BE, Carbon Dioxide CO2 are used on Class E Electrical Equipment (computers & generators)
- Wet chemical used on Class F Cooking Fats and Oils (fryers & chip pans)

When using a portable fire extinguisher, remember the acronym 'PASS'. This will help you to use the extinguisher correctly.

P. Pull out the safety locking pin

A. Aim the nozzle of the extinguisher at the base of the fire

S. Squeeze the discharge lever

S. Sweep the nozzle from side to side when attacking the fire

AS:2444 specifies the criteria for selection of portable fire extinguishers as well as the requirements for their application, location and distribution.

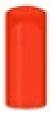
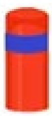
The type and number of extinguishers and their placement will be determined by the layout of a building and the fire risk areas to be covered. Portable fire extinguishers should be installed no less than 15m. from the fire hazard and no more than 40m. Total numbers of extinguishers will also be influenced by building area. The type of portable extinguisher installed will be based on the type of fire risk in that area.

AS:2444 requires that the base of any wall mounted portable fire extinguisher must be a minimum of 100mm above floor level and the top of the extinguisher should not be higher than 1.2m. for easy access in emergencies. Fire extinguishers must be visible and cannot be hidden from view and their locations should be indicated on a buildings site evacuation plan.

A location sign (red in colour with a picture of a fire extinguisher) which Indicates the location of fire extinguisher, is fixed at a height of 2m. and may require a right angle fixing bracket to make it more visible at distance.

AS:1851 covers the requirements for the routine inspection, testing and maintenance of fire protection systems and equipment. Under this standard, all portable fire extinguishers need to be tested every 6 months. Pressure testing and refill is required at least once every 5 years.

Common extinguisher types and their applications are listed below:

		Class A Flammable Materials (paper & wood)	Class B Flammable Liquids (paint & petrol)	Class C Flammable Gases (butane & methane)	Class D Flammable Metals (lithium & potassium)	Class E Electrical Equipment (computers & generators)	Class F Cooking Fats and Oils (fryers & chip pans)
	Water	Yes	No	No	No	No	No
	Dry Chemical Powder ABE	Yes	Yes	Yes	Yes	Yes	No
	Dry Chemical Powder BE	No	Yes	No	No	Yes	Limited
	Carbon Dioxide CO2	Limited	Limited	No	No	Yes	No
	Foam	Yes	Yes	No	No	No	Limited
	Wet Chemical	Yes	No	No	No	No	Yes

Activity 2

Excerpt from Commerce Building and Energy

https://www.commerce.wa.gov.au/building-and-energy/notification-and-certification-electrical-installing-work

Frequently asked questions for electricians | Department of Mines, Industry Regulation and Safety (commerce.wa.gov.au)

Note to Trainer and Assessor – **the Learner will answer Question 1**, from their own experience 'on the job' and 'off the job'.
There is no information on the Answer to **Question 1**.

The Electricity (Licensing) Regulations 1991 require electrical contractors to certify certain types of electrical installing work carried out in Western Australia.
Depending on the type of work one or more of the following may be required:

- Preliminary Notice
- Notice Of Completion
- Electrical Safety Certificate

Preliminary Notices

An electrical contractor intending to carry out any notifiable electrical installing work or cause any notifiable electrical installing work to be carried out must submit a preliminary notice to the relevant electricity network operator before the proposed electrical installing work is commenced (Regulation 51).

Some exemptions are provided in the regulation.

If the electrical installation will not be connected to an electricity network operator's system, the notice must be sent to Building and Energy.

Notices of Completion

An electrical contractor who carries out any notifiable electrical installing work or causes any notifiable electrical installing work to be carried out must submit a notice of completion to the relevant electricity network operator within **three (3) days** of completion of the work (Regulation 52).

Some exemptions are provided in the regulation.

Regulation 242 of the Electricity Regulations 1947 requires the network operator to have such a notice before connecting the electricity supply.

If the electrical installation will not be connected to an electricity network operator's system, the notice must be sent to Building and Energy.

A notice of completion is a legal document certifying that the installing work:

- has been completed;
- has been checked, tested and complies with all regulatory requirements; and
- is safe to connect to the electricity supply.

The electrical contractor must make a record of each test, inspection and verification that was carried out in accordance with the Australian/New Zealand Wiring Rules.

A copy of the notice of completion and the associated testing and checking records must be retained by the electrical contractor for a minimum of **five (5) years**.

Electrical Safety Certificates

An electrical contractor who carries out any electrical installing work (either notifiable or non-notifiable) or causes any electrical installing work to be carried out must also submit an electrical safety certificate to the person for whom the work was done **within 28 days** of completion of the work (Regulation 52B).

Some exemptions are provided in the regulations (for example, an electrical safety certificate is not required for maintenance work).

An electrical safety certificate is a legal document certifying that the installing work:

- has been completed;
- has been checked, tested and complies with all regulatory requirements; and
- is safe to connect to the electricity supply.

A copy of the electrical safety certificate must be retained by the electrical contractor for a minimum of five (5) years.

Some exemptions apply. For example, an electrical safety certificate is not necessary for maintenance work.

The certificate is a guarantee that the electrical installing work has been carried out by a licensed electrical contractor and is safe.

Lodgement of Notices and Certificates

Electrical contractors may use Building and Energy's online application 'eNotice' to lodge (electronically) preliminary notices and notices of completion with network operators (or Building and Energy) and to deliver electrical safety certificates to the relevant persons. Use of this online service is free.

As a guide, the table below gives an indication of what is notifiable work.

Type of work being carried out	Notifiable	Not Notifiable	Electrical Safety Certificate
Addition of one single final sub-circuit including its protective device		Yes	Yes
Addition of two or more final sub-circuits including their protective devices	Yes		Yes
Addition of one (or more) socket outlets (or light points) to the same existing final sub-circuit		Yes	Yes
Addition of one (or more) socket outlets (or light points) to different final sub-circuits		Yes	Yes
Addition of one RCD to protect one existing final sub-circuit		Yes	Yes
Addition of one RCD to protect more than one existing final sub-circuit		Yes	Yes
Addition of two or more RCDs to protect two or more existing final sub-circuits	Yes		Yes
Addition of one smoke alarm to an existing final sub-circuit		Yes	Yes
Replace one fuse with a circuit breaker		Yes	Yes
Upgrading of one or more submains	Yes		Yes
Addition of one or more submains	Yes		Yes
Replace one circuit breaker with one RCBO (combination RCD/MCB)		Yes	Yes
Replace two or more circuit breakers with RCBOs (combination RCD/MCB)	Yes		Yes
Replace more than one fuse with circuit breakers	Yes		Yes
Installation of solar panels and inverter system	Yes		Yes
Replace a defective main switch, lighting switch, socket outlet or lighting point		Yes	
Replace a defective hot water system, air conditioner, cook top or oven with an item of equivalent specification		Yes	
Replace one or more socket outlets or lighting points on one or more final subcircuits		Yes	

Activity 3

Effects of Electric Current

Electricity is a form of energy and when electric current flows in a conductor it creates change.

Electric current has a:

- Heating Effect
- Light Effect
- Magnetic Effect
- Chemical Effect

Heating Effect

When current flows, work is done. Electrical energy is converted to heat energy.

The heat which is produced raises the temperature of the conductor and the resistance is increased.

The heat generated is the copper loss or I^2R loss.

Some metals like silver, copper, aluminium are very good conductors of electricity.

They offer no obstruction (resistance) to the flow of electricity through them.

Light Effect

A form of energy is light. Light is obtained from heat energy and is most noticeable by making surroundings visible.

Magnetic Effect

An electric current flowing in a conductor produces a magnetic field around it.

Examples are - iron, steel, nickel and cobalt.

One of the major effects of electric current in use is the magnetic effect of electric current.

Without magnetic effect we couldn’t have motors today.

Chemical Effect

When an electric current is passed through a conducting solution, some chemical reaction takes place.

Some of the chemical effects of electric current are:

- Bubbles of gas may be formed at electrodes
- Deposits of metal may be seen on electrodes
- Change of colour of solution may occur

Corrosion is a wearing away due to chemical reactions, mainly oxidation. It occurs whenever a gas or liquid chemically attacks an exposed surface, often a metal.

Activity 4

Excerpt from Electricity (Licensing) Regulations 1991, Clause 54B and 55.

https://www.legislation.wa.gov.au/legislation/statutes.nsf/main_mrtitle_1355_homepage.html

54B. Application of regulation 55 in relation to certain network operators

1) Regulation 55 does not apply to electrical work carried out on or near the service apparatus of a major network operator if the work is carried out by or on behalf of the network operator.
2) Regulation 55 applies in relation to the networks of the following network operators as if regulation 55(2)(b)(i) were deleted:
    a) a person who is a network operator under the Electricity (Network Safety) Regulations 2015 regulation 4(1)(h),
    b) an exempt operator who is exempt under the Electricity Industry Exemption Order 2005 clause 13 or 17.

55. Electrical Work on or Near Energised Electrical Installations

1) A person who carries out electrical work, or causes electrical work to be carried out, on or near an energised part of an electrical installation commits an offence unless the person carries out the work, or causes the work to be carried out, under sub regulation (2).
2) A person may carry out electrical work, or cause electrical work to be carried out, on or near an energised part of an electrical installation if:
    a) a risk assessment has been undertaken by a competent person who is familiar with the type of work to be carried out, and the competent person is satisfied that:
        i. there is no reasonable alternative to carrying out the work while the part of the electrical installation is energised, and
        ii. the risks identified by the risk assessment are or can be reduced to as low as reasonably practicable, and
        iii. the work can be carried out safely, and
    b) if the Occupational Safety and Health Regulations 1996 regulation 3.143 does not apply to the work, a safe work method statement for the work has been prepared in accordance with regulation 3.143(4) of those regulations, as if the work were high-risk construction work and the place where the work is to be carried out were a construction site, and
    c) (suitable safety and personal protective equipment is used by the person carrying out the work.

Excerpt taken from 'Safe Working Guidelines for Electrical Workers'

Electrical Isolation and De-Energisation of Equipment

Before commencing any electrical work, the circuits or equipment to be worked on must be disconnected from all sources of electricity supply, the isolation points physically secured to prevent inadvertent re-energisation, and proven to be de-energised.

Principles and safe practices for the effective de-energisation of electrical circuits and equipment are provided in Building and Energy's 'Code of Practice for Persons working on or near energised electrical installations'

The key steps are summarised below for reference.

Essential steps for effective De-Energisation of equipment

Equipment is energised Actions required

1. Isolate - Identify and disconnect all sources of electricity:
   - switch of isolator/circuit breaker, and
   - remove fuses or other components.
2. Secure - Secure the isolation:
   - lock isolator/circuit breaker in 'OFF' position, and
   - fit danger tag at isolation point.
3. Test - Test that equipment is de-energised:
   - check test instrument with known voltage source, then
   - test equipment is de-energised, then
   - re-check test instrument with same voltage source.

Equipment is de-energised

Securing the Isolation

Locks

Where a facility exists to lock a switch in the 'OFF' position, it must be used. Where a facility does not exist, a portable lock out device ('lock dog') must be fitted to the switch mechanism to prevent closing.

Locks are for the safety of personnel and:

- they must be uniquely keyed so that they can be fitted and removed only by the person owning the lock,
- all persons involved in carrying out the work must fit their own lock at the same isolation point(s). This may require the use of a multi-lock security device,
- they must be clearly labelled (with a personal identification tag or Danger tag) to identify the owner and the nature of the electrical work being undertaken, and
- they must be removed upon completion of work or at the end of the shift (if the work will be continued by others, who must fit their own locks).

Danger Tag

- A Danger tag on an item of equipment is a warning to all persons that the equipment must not be operated, as lives may be placed in danger.
- Danger tags are for the safety of personnel and:
  - they must be attached in a prominent position at each isolation point,
  - they must be fitted and removed only by the person who signed the tag,
  - all persons involved in carrying out the work must fit their own Danger tag at the same isolation point(s), and
  - they must be removed upon completion of the work or at the end of the shift (if the work will be continued by others, who must fit their own Danger tags).

Out of Service Tag

- This tag is used to identify appliances or equipment that are out of operation for repairs or alterations or are still in the process of being installed. While an Out of Service tag is fitted, the appliance or equipment must not be operated.
- Out of Service tags are for the safety of personnel and security of equipment and must be:
  - attached in a prominent position at the point of isolation of the appliance or equipment that is being worked on
  - fitted and removed only by authorised persons.

Note to Trainer and Assessor – **The Learner will answer question 4**, **Question 4**, from their own experience 'on the job' and 'off the job'.

There is information on the Answer to Question 4 towards the end of the Resource Book titled 'Testing of a Single Phase Installation'.

Question 4 will remain in the Knowledge Portfolio.

What to do in an Electrical Emergency

Step 1: Don't touch someone receiving an Electric Shock

If one of your colleagues receives a serious electric shock, your first reaction will likely be to go to their aid.

But first, stop and think. The human body is an excellent conductor of electricity, meaning that the charge that just passed through your co-worker could easily move into you if you make contact with them. Given that electricity has the capacity to kill or seriously injure, limiting the number of people exposed to the shock should be your number one priority.

In some cases, individuals can appear to be 'stuck' to electrical currents. What's actually happening here is that the voltage is sufficiently high to cause the victim's muscles to contract. This means they can't let go of the cable or object administering the shock, which is clearly very dangerous.

Additionally, be careful if there is water spilled on the site. Water conducts electricity, so until the power is turned off (see step 3), take precautions when moving around the area.

Step 2: Call Emergency Services

Ideally, you'll have someone with you so that steps two and three can happen at the same time. However, if you're alone, it's important that you phone emergency services as soon as possible. Victims of serious electric shocks will need treatment from medical professionals, so get the emergency crew on their way before you try and deal with anything further yourself.

When you call, give as much detail as possible on where you are and what's happened – this will allow the crew to prepare enroute.

Step 3: Turn off the Power

If it's safe to do so without putting yourself in danger, turn off the power – this makes the emergency site much safer to move around when the ambulance arrives, and prevents further damage.

In situations where you can't turn the power off safely, try to separate the victim from the electricity source using a dry, non-conductive item such as a wooden broomstick, or the rescue crook from a low voltage rescue kit if one is readily available.

Step 4: Administer First Aid

Only once the victim is away from the current can you approach them and begin first aid. Injuries from electric shocks can range from serious burns to cardiac arrest and death, and you need to know how to deal with different scenarios:

If the individual is responsive – Attend to their injuries, for example place burns under cold water for 20 minutes, and then cover with dressings. If you don't have a first-aid kit with you, kitchen glad wrap is suitable, if it's not applied too tightly. Never put oils or ointments on burns.

If the individual isn't breathing – For unconscious victims who aren't breathing, perform cardiopulmonary resuscitation (CPR) until medical teams arrive to take over from you.

Before professionals arrive, knowing how to treat an injured person can be the difference between life and death for those involved in electrical emergencies. This is why it's important that electrical technicians are fully trained in how to perform first aid.

Note: The most effective way to tackle a workplace emergency is to plan to respond before an emergency happens. Be proactive NOT reactive.

Activity 5

First Aid

Responsibilities of the First Aider:

- The responsibilities of a first aider are to provide initial care of the ill or injured, giving swift and efficient treatment of the injury.

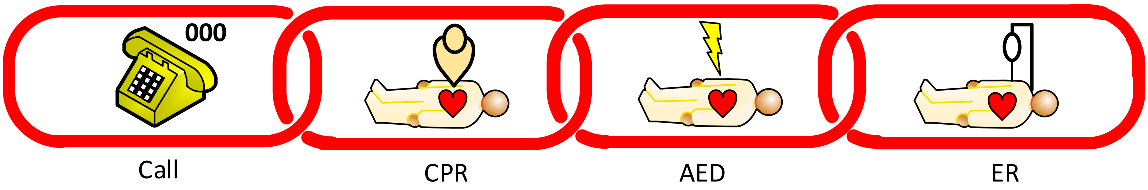
Priority action plan:

- The priority action plan as suggested by the St John Ambulance is a step by step procedure for managing an incident.
- The acronym DRSABCD is used as a guidance for the action plan.

Procedures required at an accident scene:

- Look around for dangers
- Check casualty and their response
- Call 000 or (112 from mobile phones)
- Care for injuries

The Chain of Survival



Accessing Emergency Services

- Numbers to call:
  - Landline: 000
  - Mobile: 112 or 000
- 3 points to remember when making a call:
  - State which emergency service you require and the State and Town in which you are located
  - Stay on the line until connected
  - Give as much information as you can

Procedures for performing CPR

DRSABCD

The DRSABCD Action Plan assists you to prioritise your actions including primary assessment of the casualty for any life threatening conditions and what management to put in place.

D – Danger

Check for danger, approach with care and do not put yourself in danger.

- Look for hazards
- Assess the risks
- Ensure safety to all

Hazards May be Present:

- Electricity
- Fumes
- Fallen power lines
- Falling masonry
- Risk of explosion
- Slippery surfaces

R - Response

Look for a response. Is the victim conscious? Gently touch and talk to the victim, as if you are trying to wake the victim up. If there is no response, get help.

Check for the casualty's response:

- C – Can you hear me?
- O – Open your eyes?
- W – What is your Name?
- S – Squeeze my hands

Signs of Life checked:

- Unconscious, unresponsive, not moving, not breathing normally – Call for an Ambulance (use bystanders or make the call yourself)

S - Send for help

Call emergency services:

- Dial triple zero (000) – ask for an ambulance.

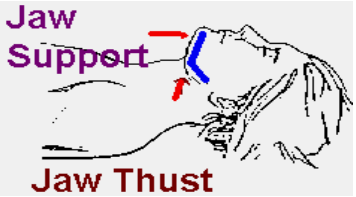
A – Airway

- Check airway – drain any fluid or remove debris.

Don't move the person.

Check the airway. Don't move the person. Gently tilt their head back, open their mouth and look inside. If fluid and foreign matter is present, gently roll them onto their side. Tilt their head back, open their mouth and very quickly remove any foreign matter (for example, chewing gum, false teeth, vomit).

It is important not to spend much time doing this as performing CPR is the priority. Chest compressions can help to push foreign material back out of the upper airway.



B – Breathing

To check breathing:

- Look – for the rise and fall of the chest
- Listen – for air moving in and out of the mouth
- Feel – for air on your cheek and hand on the chest

Sign of Life Checked:

- Not Breathing Normally
- Opening the Airway

Methods of Rescue Breathing:

- Mouth to mask
- Mouth to mouth
- Mouth to nose

C – Compression

Start CPR:

Performed by one person.

If still no signs of life:
- Find centre of chest
- Commence CPR
- 30 compressions: 2 rescue breaths (adult/infant - approximately 1/3 the depth of the chest)
- 5 cycles per 2 minute6
- Rotate providers every 2 minutes (for infants/children and adults)
- Continue until emergency personnel arrive.

CPR can be performed by two persons (one performing chest compressions and one performing rescue breaths).

D - Defibrillation

Apply **As Soon As Possible** (ASAP). (see following pages for more information)

Follow the voice prompts.

CPR Mask

A CPR mask, officially known as a barrier device, is for keeping you, the rescuer, safe.
For an intimate partner or immediate family member, a barrier device is probably not necessary unless the victim is known to have an infectious disease.

Automated External Defibrillator (AED)

When to use an AED:

Only use an adult AED on any person over the age of eight years, who is unresponsive and not breathing normally. For children under the age of eight, ideally, a paediatric AED and pads should be used.

Using an AED on children and infants is slightly complicated due to their size and age. The adult AED could deliver too great a shock and may have inappropriate pads for the child's size. For children aged between 1 and 8 years use paediatric pads.

If the AED is child compatible it should have a diagram indicating where to place the pads.
- Attach a semi-automatic defibrillator as soon as possible
- Follow prompts of the AED.

No Signs of Life:
- Not Moving
- Unconscious
- Unresponsive
- Not Breathing Normally
- Commence CPR

An automated external defibrillator (AED) is a portable device that checks the rhythm of the heart. If needed, it can send an electric shock to the heart to try to restore a normal rhythm.

AEDs are lightweight, battery-operated portable devices that are easy to use. Each unit comes with instructions, and the device will give voice prompts to let you know if and when you should send a shock to the heart. CPR must be continued until the AED is turned on and the pads are attached.

When to use an AED:

An AED should be used **As Soon As Possible** (ASAP) when a person is having sudden cardiac arrest (SCA) or on a person who is unconscious and unable to respond when you call or shake him or her.

Using an AED on a person who is having SCA can save the person's life.

The most common cause of SCA is an arrhythmia called ventricular fibrillation. The ventricles of the heart have three states - rest, normal beat and fibrillation. Fibrillation is where the heart's lower chambers don't beat normally causing them to quiver very rapidly and irregularly.

When not to use an AED:

Do not use an AED if signs of life are present. Note: An AED will automatically analyse the heart rhythm of the casualty and inform you, the rescuer, whether a shock is advised.

Activity 6

Perform Rescue from a Live LV Panel/Switchboard

Why are Correct Rescue Procedures Necessary?

Procedures:

It is important that the correct rescue procedures are carried out with the:

- minimum of risk
- minimum amount of time.

Low Voltage (LV) Rescue Kit for use when working on low voltage power supplies and switchboards
The kit must be complete and ready for use in an emergency switchboard rescue.

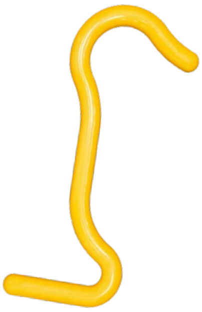
LV rescue is High risk, and the rescuer must have the correct gear and know how to use it when rescuing someone while working on a switchboard.

Low Voltage Rescue Kits come complete in a bag and includes the following contents:

- Pair of electrically tested 1000V insulating gloves.
- Fibreglass fire blanket.
- Trauma/burns dressing.
- Insulated rescue crook.
- Insulated torch.
- 'Isolate Here in Emergency' sign.

Extra to contents:

- First Aid Booklet

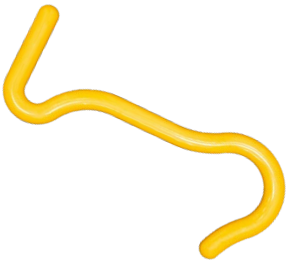


LV rescue kits should be available for any electrician who works on or near switchboards. On at least six-monthly intervals low voltage rescue kits are to be fully inspected and items are to be tested in accordance with manufacturer requirements.

Before rescuing a victim:

- Ensure all prerequisites/permits are met.
- Check that the contents of the low voltage rescue kit are operational and have been tested, as required. Refer AS/NZS 4836 Section 5.
- Gloves – air and check test - last test date and next test date due.
  Insulating gloves are to be a minimum length of 360mm and are to be individually labelled or marked with a means of establishing the last test date and next test date due.

- Rescue crook – visible defects and test tag.



- Torch – visible defects and batteries

- Ensure work area is clean and clear access available.
- Identify isolator and attach 'Isolate Here in Emergency' sign.

Activity 7 Answers found in AS/NZS 3000

Activity 8 Question 1 - Answers found in Definitions section, and Question 2 - found in AS/NZS 3000, Appendix I2, Table I1. Search AS/NZS 3000 Index under – 'Protective Devices – ratings'.

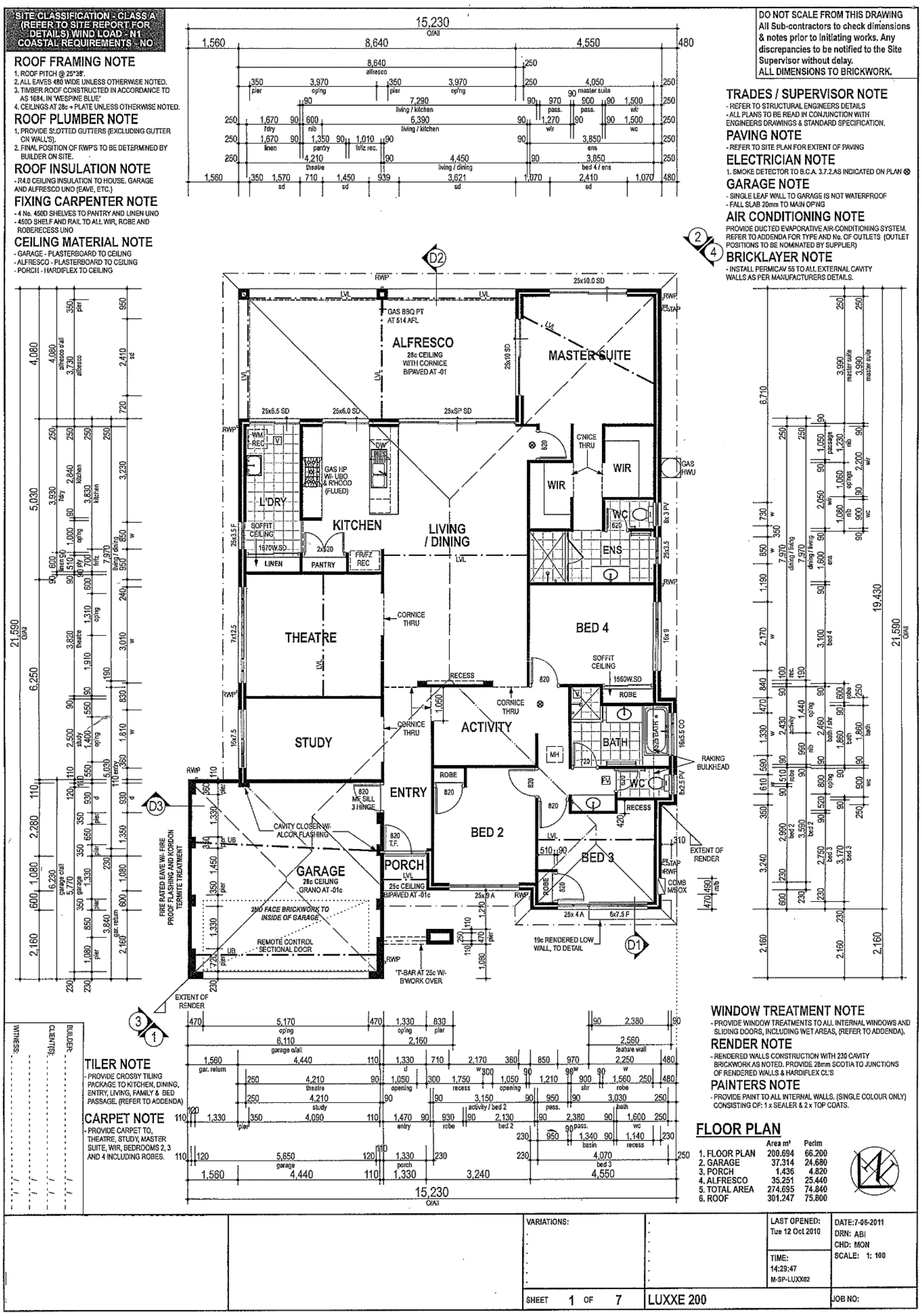
Activity 9

Note to Trainer and Assessor:

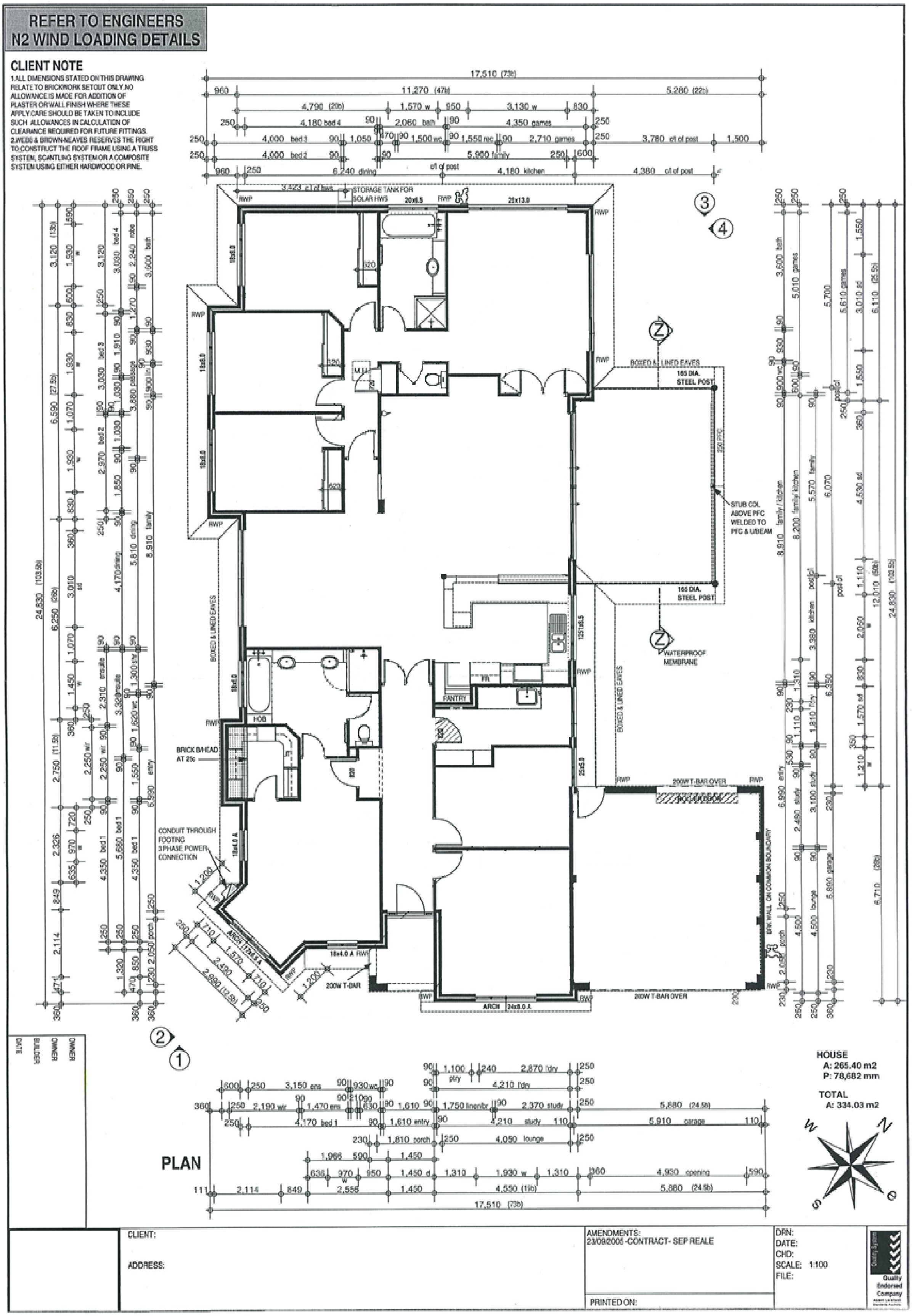
The Learner will answer question 1, from the information on the circuits provided in the question.

The Learner can answer question 1, referring to the definitions list.

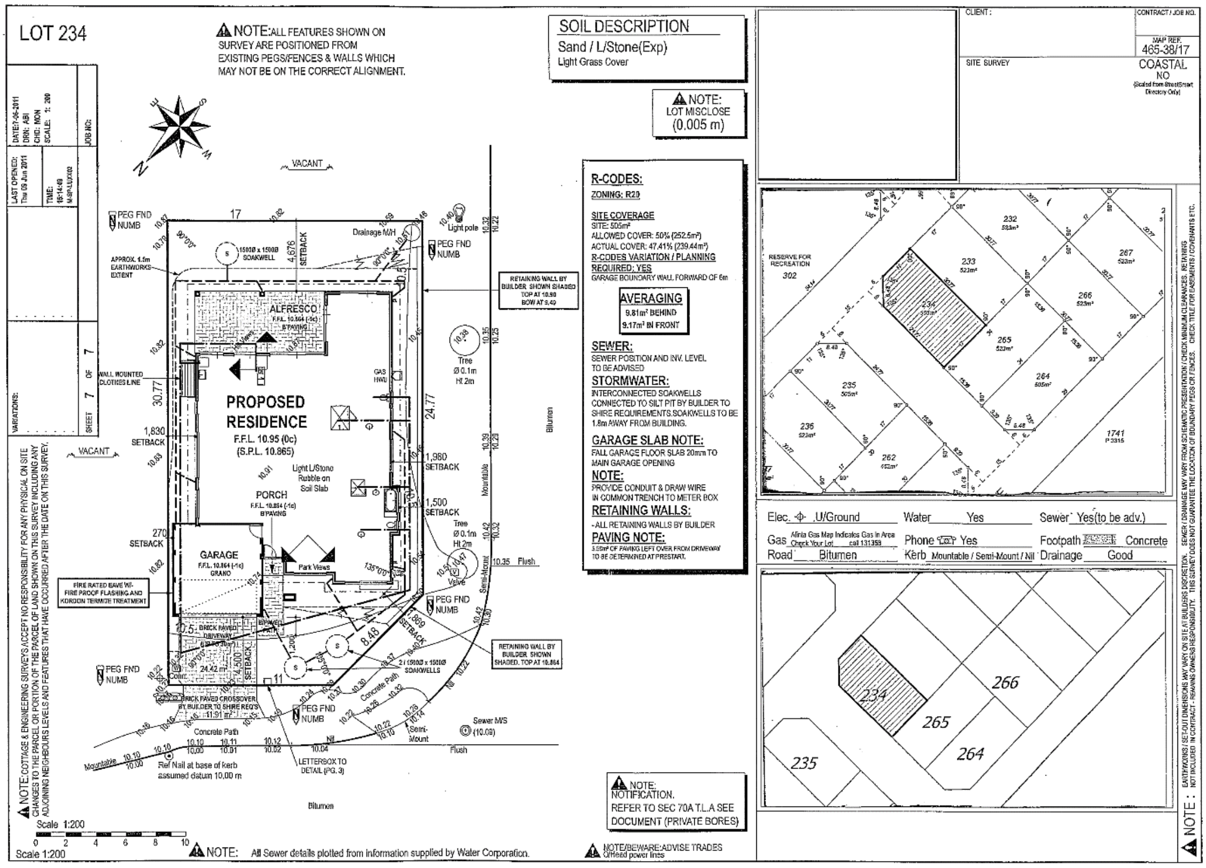
Examples of House Plans



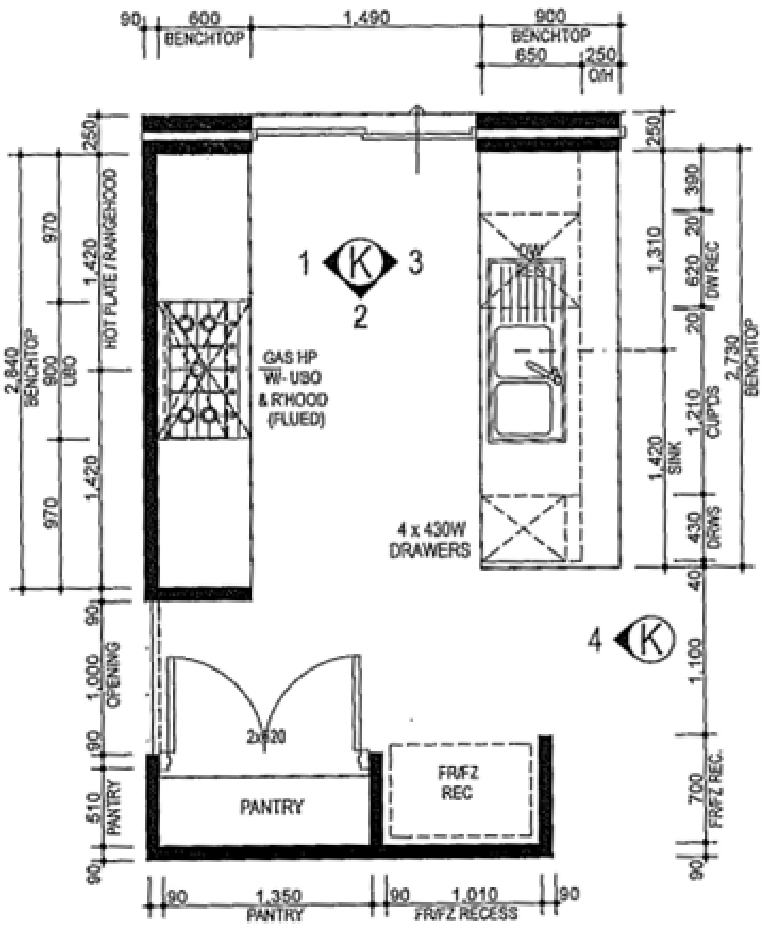
Floor Plan



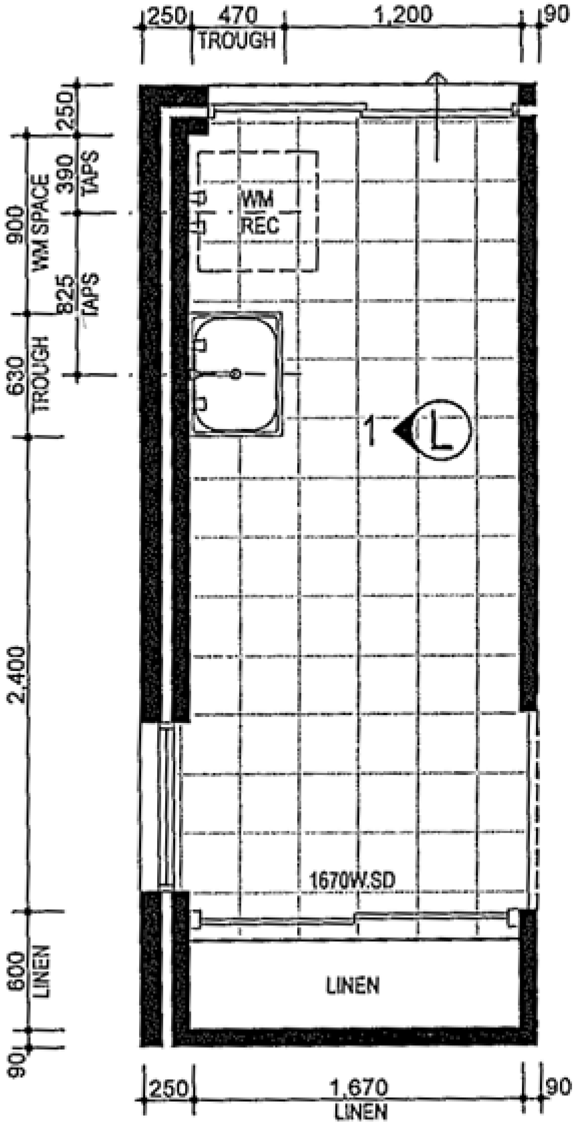
Floor Plan with Measurements



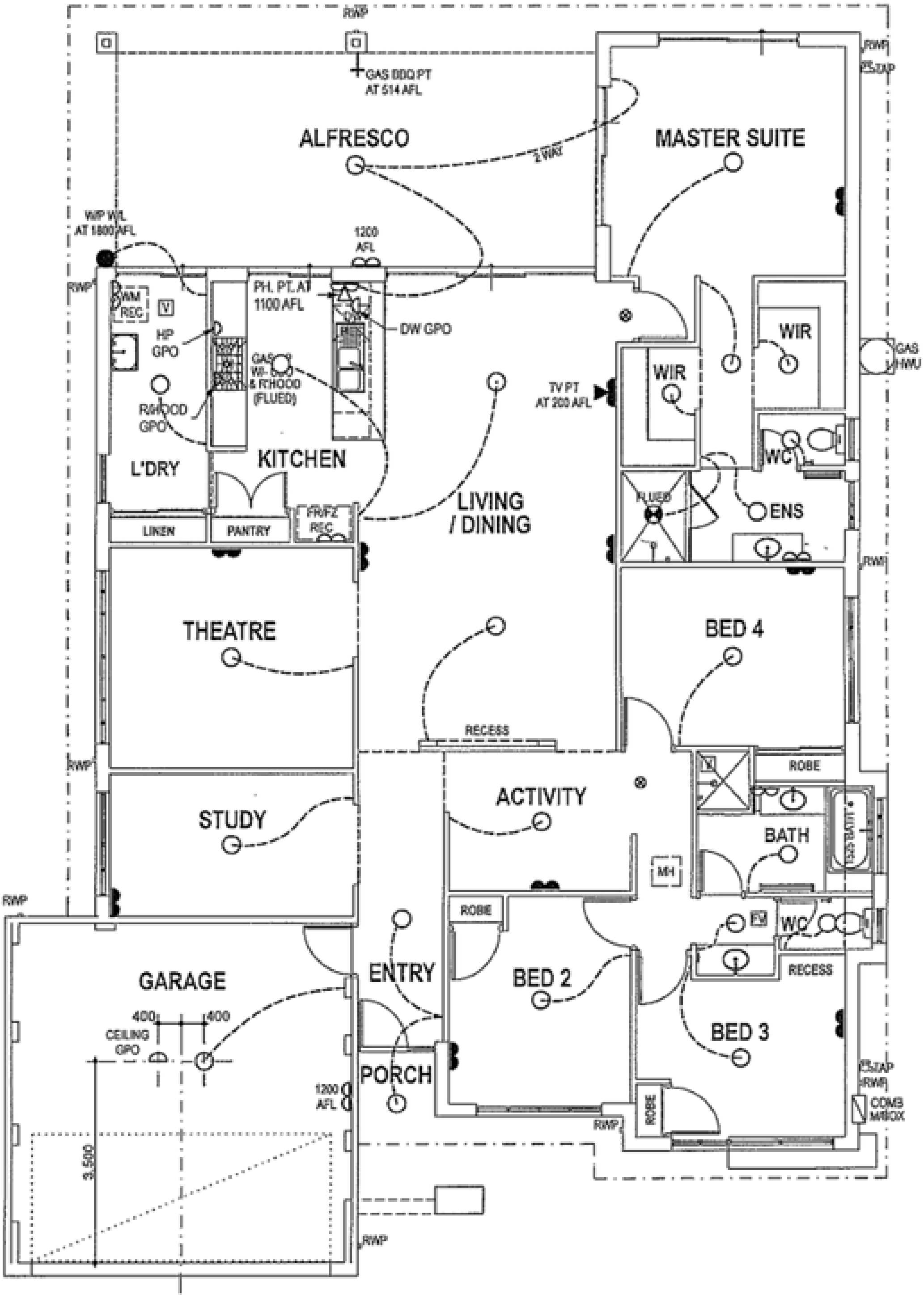
Site Plan



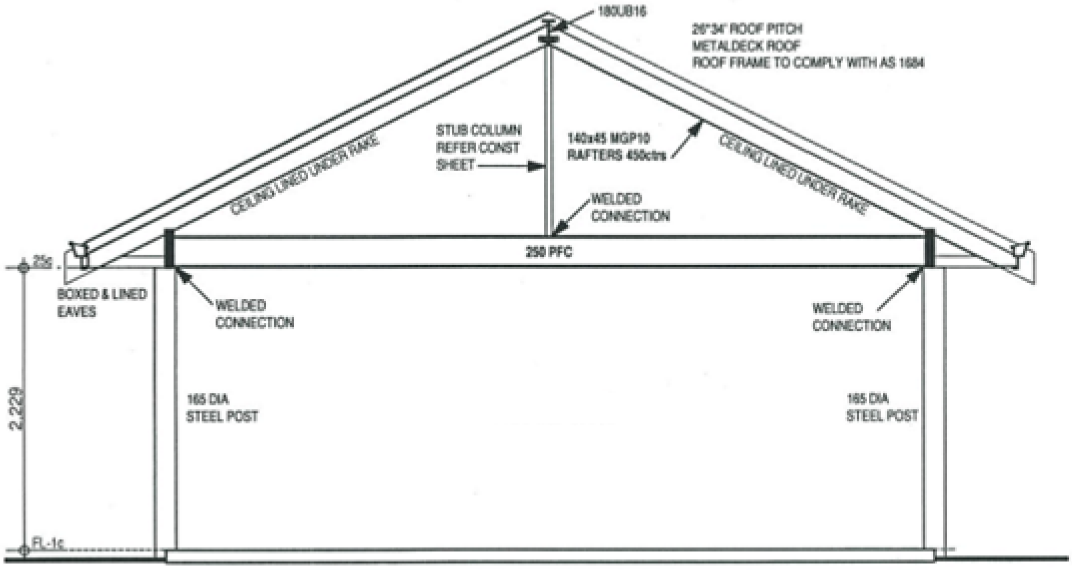
Kitchen Plan

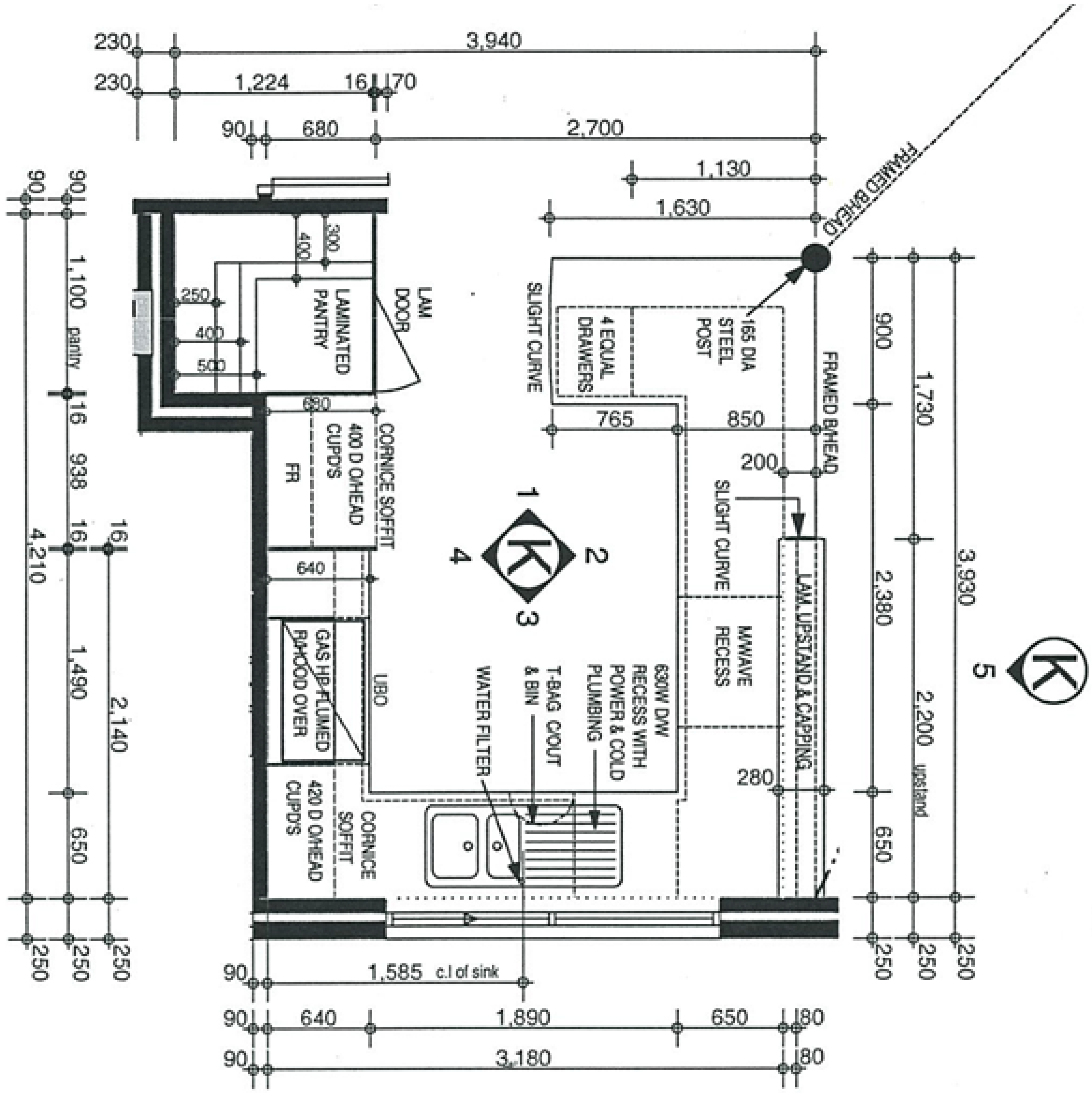


Laundry Plan

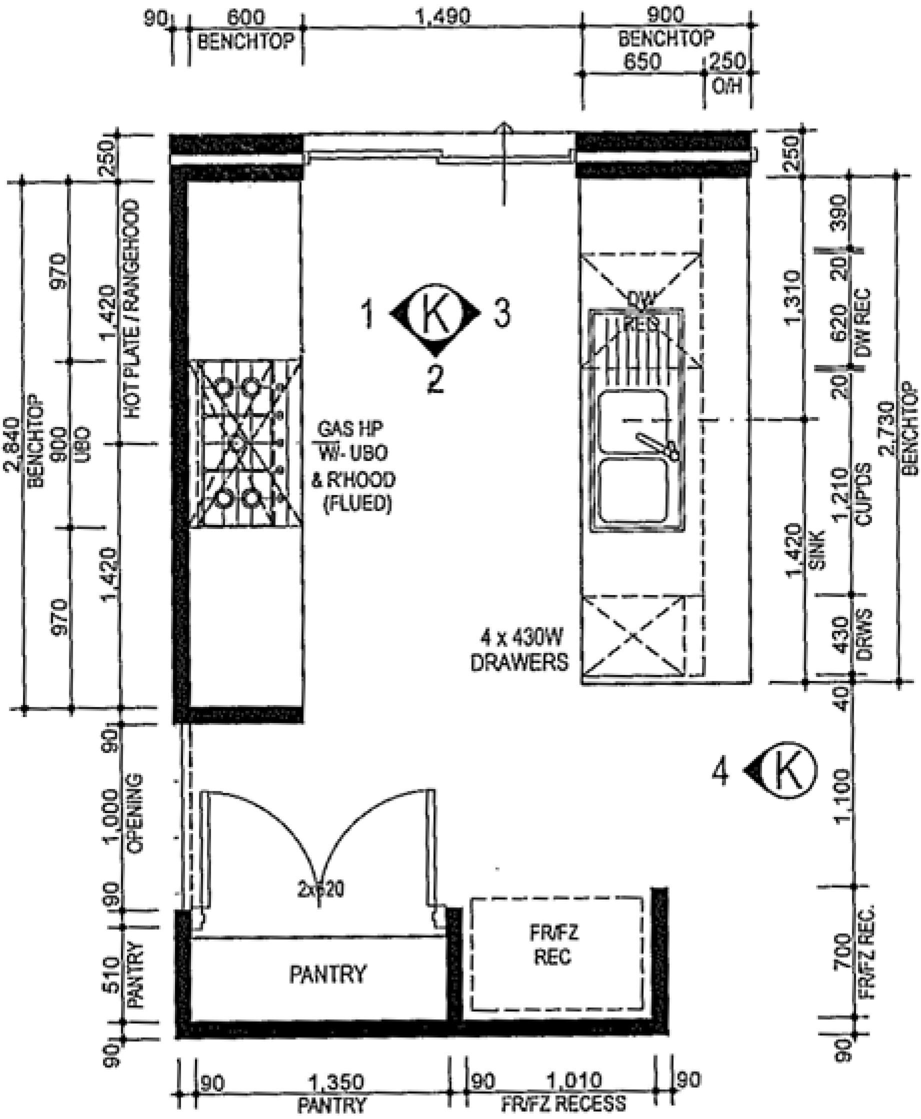


Electrical Plan





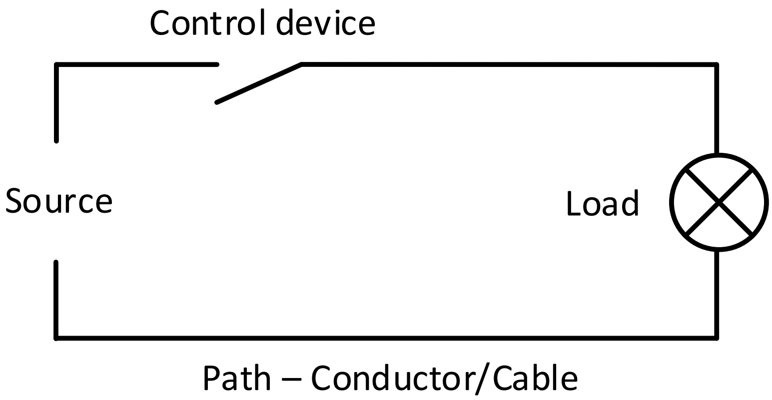
Detailed Kitchen Plan



Detailed Kitchen Plan

Activity 10 & 11

Basic Circuit

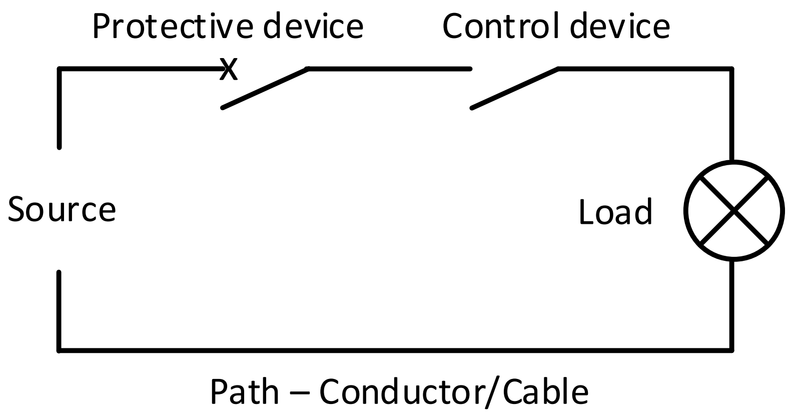


A basic circuit is made up of:

1) Control – switch
2) Load – lamp/light (LED downlight)
3) Source/Supply – a.c. or d.c.
4) Conductor – path

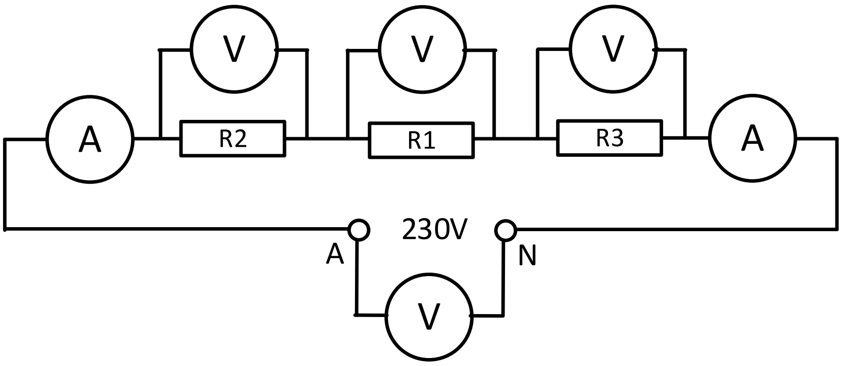
Protective Device

1) Circuit breaker/RCBO



Series Circuit

- One path for current to flow through all components.
- The same amount of current flows through each component.
- Individual voltage drops across each component.
- The sum of the voltage drops adds up to the applied voltage.
- The sum of the resistances in the circuit adds up to the total resistance.



Examples of Series Circuits

- Hot water systems – control circuits – thermostat is in series with the element/s
- Light circuit – switch is in series with the light
- Windings in three phase and single phase induction motors
- Safety switches installed in electric lawnmowers – two switches in series with each other, both need to be pressed for the lawn mower to work
- Protective devices – circuit breaker, fuse – connected in series with loads.

Formula

Series Circuit

$\mathrm{Rtotal} = \mathrm{R1} + \mathrm{R2} + \mathrm{R3}$

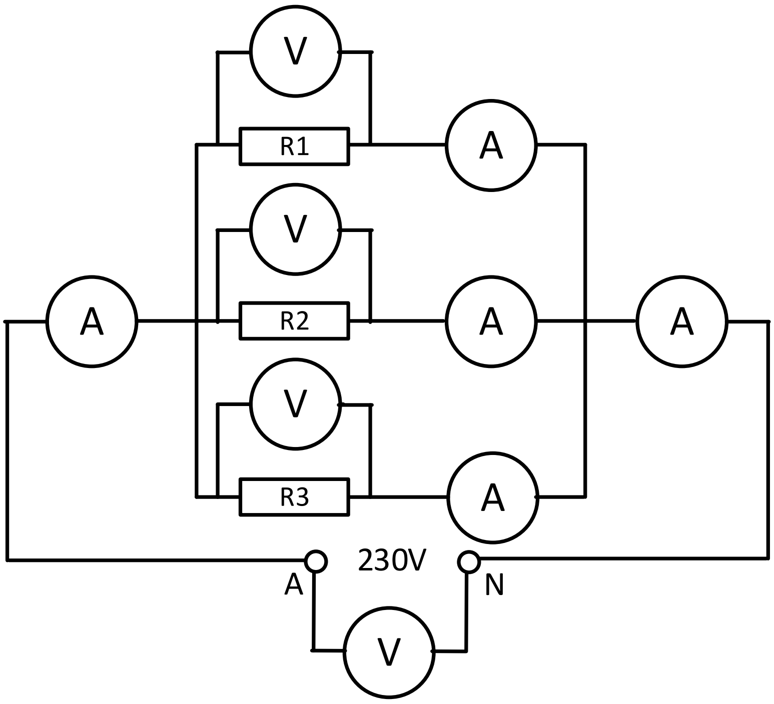
$\mathrm{Vsupply} = \mathrm{V1} + \mathrm{V2} + \mathrm{V3}$

$\mathrm{Isupply} = \mathrm{I1} = \mathrm{I2} = \mathrm{I3}$

$\mathrm{Ptotal} = \mathrm{P1} + \mathrm{P2} + \mathrm{P3}$

Parallel Circuits

- The same voltage appears across each branch. Your house is cabled as a parallel network. E.g. socket outlets, lighting. Each appliance is 230V.
- The total current in a parallel circuit divides into the branch currents.
- The more resistances there are in a parallel circuit the smaller is the total resistance.
- Total power is the sum of the power occurring in individual branches.
- The sum of all the currents add up to give the total current from the supply.



Examples of Parallel Circuits

- Socket outlets installed in a room
- Light circuits installed in a room
- Electronic circuits

Formula

Parallel Circuit

$$\mathrm{Rtotal} = \frac{\mathrm{R1 \times R2}}{\mathrm{R1} + \mathrm{R2}}$$

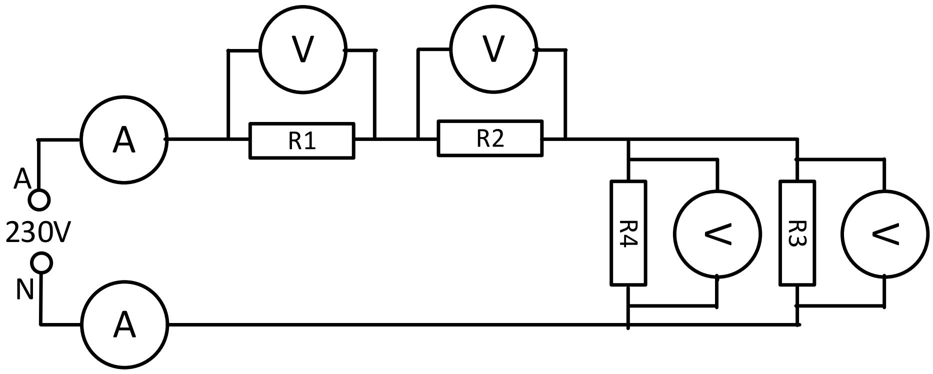
$\mathrm{Vsupply} = \mathrm{V1} = \mathrm{V2} = \mathrm{V3}$

$\mathrm{Isupply} = \mathrm{I1} + \mathrm{I2} + \mathrm{I3}$

$\mathrm{Ptotal} = \mathrm{P1} + \mathrm{P2} + \mathrm{P3}$

Series/Parallel Circuits (Combined, Compound, Complex, Multiple)

- Made up of components in series and parallel.
- Work out which components are clearly shown. E.g. the circuit below has 2 x components in series (R1 and R2) and 2 x components in parallel (R3 and R4).
- Calculate the circuit below by:
  1. Calculating the parallel part of the circuit first (R3 and R4) which will leave a series circuit with three components (R1 , R2 and (R3/R4) which would be R3.
- Depending on if the circuit ends up as a series or parallel circuit, use the formulas above for series and parallel.



Power

$P = I^2 \times R$

$P = V \times I$

$P = \frac{V^2}{R}$

Electrical Devices

Control device – interrupts the flow of current in a circuit e.g. switch

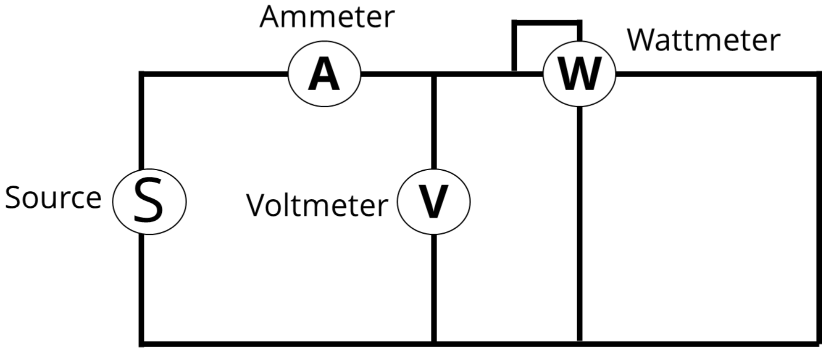
Protective Device

- Circuit breaker (C/B) – provides protection of equipment against over-current.
  Types of circuit breaker tripping mechanisms – thermal, magnetic and thermal/magnetic
- Fuse - provides protection of equipment, motors, against overcurrent.
  Type – High rupturing capacity (HRC) cartridge fuse
- Residual current device (RCD) – provides protection for people and is designed to immediately switch off the supply of electricity when electricity leaking to earth is detected at harmful levels.
- Residual current breaker with over-current (RCBO) – provides protection of equipment and people and is designed to immediately switch off the supply of electricity when electricity leaking to earth is detected at harmful levels and overload and short circuit currents.

Electric Circuits

- Open circuit – when the current path is not continuous. When a switch is turned 'off' the path is now an open circuit.
- Closed circuit – when current can flow around a circuit e.g. a light is on. When a switch is turned 'on' the circuit is closed and current can flow.
- Short circuit – when a fault has occurred causing a protective device to trip or open circuit.

Connecting of Test Equipment in a Basic Circuit



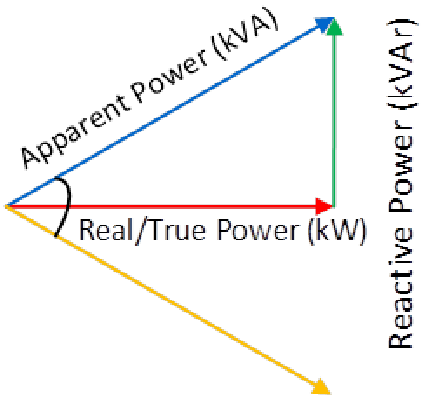
Typical test equipment includes:

1) Ammeter – used to measure current in a circuit
2) Voltmeter – used to measure voltage in a circuit
3) Wattmeter – used to measure power in a circuit

Power Factor in a Circuit

To calculate power factor, you need a power analyser or power analyser that measures both power (kW) and apparent power (kVA), and to the ratio of kW/kVA.

The power factor formula can be expressed in ways:



quality
working
calculate

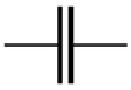
other

PF = (True power)/(Apparent power)

OR

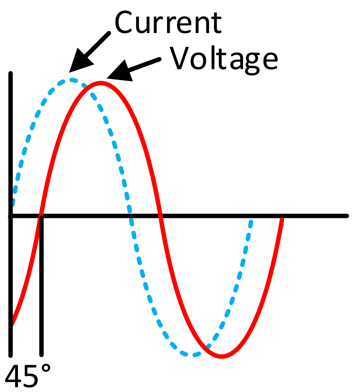
PF = W/VA

Circuits with a capacitive load will be leading

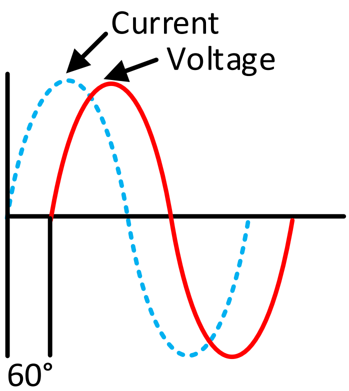


Inductive loads will be lagging.

Leading and lagging power factors are the two major terms associated with the power factor of the AC electrical system. The crucial difference between leading and lagging power factor is that in case of leading power factor the current leads the voltage. As against in case of lagging power factor, the current lags the supplied voltage.



Voltage lags the current by 45°



Current leads the voltage by 60°

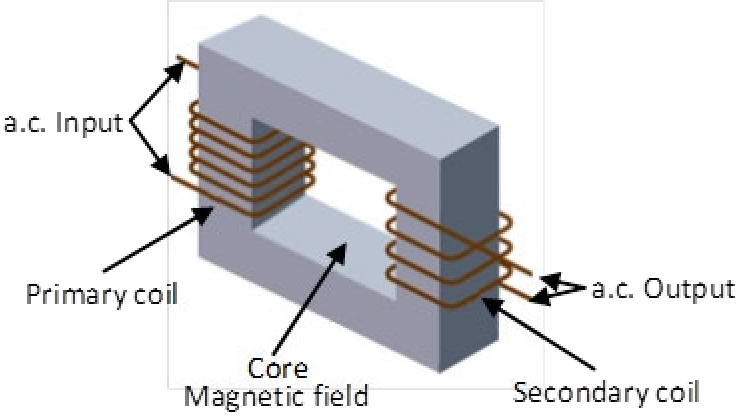
Activity 12 Answers found in AS/NZS 3000
Activity 13 Answers found in AS/NZS 3000
Activity 14

Note to Trainer and Assessor – Answer to **Question 1** is a diagram which the Learner will answer from their own experience 'on the job' and 'off the job'. There is also a hint given to the Learner at the start of the question. **Questions 3 – 5** are found in AS/NZS 3000.

Transformers

A transformer uses induction to change the voltage of alternating currents, it can increase the voltage or decrease the voltage:

- Step-up transformer – increases the voltage
- Step-down transformer – decreases the voltage



A transformer is an inductor with two separate windings.

1) Primary winding/coil – A.C. is supplied to the coil – Input – small csa winding
2) Secondary winding/coil – A.C. supplies the load – Output – large csa winding.

A transformer also has a core which the coils are not electrically connected to. They are wound around the iron core.
The alternating current in the primary produces an alternating magnetic field in the core which then induces an alternating current in the secondary.

There are different types of transformers:

- Single phase transformer – Only have one set of primary and secondary windings
- Three phase transformer – Constructed with three sets of primary and secondary windings
- Step-up transformer - Converts the voltage on the primary side into a higher voltage on the secondary side.
- Step-down transformer - Converts the voltage on the primary into a lower voltage on the secondary.
- Isolation transformer – The voltage in is the same voltage out, it does not adjust any voltage levels within an electrical circuit. The windings on the primary side and the secondary side always have the same ratio.
- Air-core transformer - Does not have a physical magnetic core. The linkage between the primary and secondary windings is made entirely with air.
- Current transformer – Along with voltage or potential transformers, it is an instrument transformer. Provides a current in its secondary coil that is proportional to the alternating current flowing in its primary. Large currents can be safely measured.
- Auto-transformer – Has only one winding. Parts of the same winding act as both the primary winding and secondary winding sides of the transformer.

Common features of transformers:

- The input and output frequency is the same
- Transformers all use the law of electromagnetic induction
- The primary and secondary coils of all transformers do not touch. Power is transferred through the magnetic flux.
- Transformers do not use any internal moving parts

Testing Transformers

Single phase Transformer

Visual Inspection

- Casing/Frame
- Terminations/Connections
- Wiring
- Nameplate

Testing of earthing continuity

- Earth point to metal parts (metal screws, frame, housing) = <0.5Ω

Polarity and Correct Circuit Connections

- One side of primary winding to other side of primary winding = low or high continuity*
- One side of secondary winding to other side of secondary winding = low or high continuity*

*These will determine if the transformer is step up or step down

Insulation Resistance Test (Clause for reference AS/NZS3000 8.3.6)

- One side of primary winding to one side of secondary winding = >1MΩ
- One side of primary winding to earth point = >1MΩ
- One side of secondary winding to earth point = >1MΩ

Three Phase Transformer

Visual Inspection

- Casing/Frame
- Terminations/Connections
- Wiring
- Nameplate

Testing of earthing continuity

- Earth point to metal parts (metal screws, frame, housing, shaft) = <0.5Ω

Polarity and Correct Circuit Connections

- One side of A winding to other side of A winding
- One side of B winding to other side of B winding
- One side of C winding to other side of C winding

Continuity (Ω) results of each of these should be the same or close to

Insulation Resistance Test (Clause for reference AS/NZS3000 8.3.6)

- One side of A winding to earth point = >1MΩ
- One side of B winding to earth point = >1MΩ
- One side of C winding to earth point = >1MΩ
- One side of A winding to one side of B winding = >1MΩ
- One side of A winding to one side of C winding = >1MΩ
- One side of B winding to one side of C winding = >1MΩ

Formulas

Calculating what the output is from a transformer or to calculate how to design a transformer to make a voltage change.

$$\frac{\text{primary voltage}}{\text{secondary voltage}} = \frac{\text{number of turns on the primary coil}}{\text{number of turns on the secodary coil}}$$

$$\frac{V_P}{V_s} = \frac{n_p}{n_s}$$

Where:
Vp = the potential difference in the primary (input) coil in volts (V)
Vs = the potential difference in the secondary (output) coil in volts (V)
Np = the number of turns on the primary coil
Ns = the number of turn on the secondary coil
Note: In a step-up transformer, Vs > Vp. In a step-down transformer, Vs < Vp.

Calculating power

$P = V \times I$

Calculating the power output from a transformer.

$Vs \times Is = Vp \times Ip$

Websites

https://www.youtube.com/watch?v=zjUMQ-itHC8&t=11s

https://www.youtube.com/watch?v=0x8D2A_LdeA&t=212s

https://www.youtube.com/watch?v=GJm-FOMeG4E&t=109s

Safe Working Procedures when Connecting and Testing Transformers

Transformer Safety Practices

- Inspect your transformer thoroughly to prevent or minimize breakdowns. Before installation, monitor your transformer by checking for any burnt odour, damaged power cords and connectors or any parts that are improperly installed.
- Use protective equipment and pay close attention to specific ratings for the transformer's voltage output. Keep over current protection of conductors and circuits set to the manufacturer's standards.
- Keep the power off when working on the transformer. Make sure there is zero electrical leakage or continuity between the current source and the system.
- Learn the maximum voltage requirements of your transformer. Be careful of system overload from a single transformer, with the understanding that multiple transformers help balance the impedance of each load.
- Transformer grounding should be in place at all times. It prevents the accumulation of static charges and protects the windings from coming in contact with the core or enclosures.
- Keep spare nuts, bolts and other objects away from your work so that they don't touch or fall into the transformer.
- Always keep your transformer and all of its components dry and free from any moisture or water. To protect unskilled onlookers, set up caution signs that warn people to keep away from danger.
- If any irregularity or abnormality is observed in the functioning of the electrical transformer, it must be shut off, and all the cables and power cords must be unplugged before analysing which part of the transformer is malfunctioning.
- Any maintenance work must only be undertaken after the equipment is de-energized and tagged out and the circuit is shut down. This is necessary to ensure that there is no leakage of current or continuity between the horse current and the system.
- Set up caution signage to prevent unqualified individuals from performing maintenance on your transformer.

Current Transformer

When a current transformer is used to measure current, the secondary winding of the transformer is connected to a measuring device such as an ammeter or a wattmeter. However, when no measuring device is connected, the output terminals of the current transformer should be shorted together.
This is because if the secondary winding is left open, it will result in a very high potential difference being induced in the core of the transformer and permanently damage it.

Shorting the secondary winding of a current transformer ensures that the primary winding looks like a short circuit and does not change the current being measured. The load across the secondary winding should be kept low impedance to minimize the primary impedance.

Activity 15

Excerpt from AS/NZS 3012.

1.1 SCOPE

This Standard sets out minimum requirements for the design, construction and testing of electrical installations that supply electricity to appliances and equipment on construction and demolition sites, and for the in-service testing of portable, transportable and fixed electrical equipment used on construction and demolition sites.

In Australia only, for a single domestic residence intended to be occupied as a residential0 housing unit, or adjoining units each with a separate exterior entry and intended to be occupied as residential housing units, the requirements of this Standard are modified as detailed in Appendix A.

1.2 APPLICATION

Electrical installations on construction and demolition sites shall be carried out in accordance with AS/NZS 3000, except as modified herein, and with the applicable additional requirements of this Standard.

This Standard shall be read and used in conjunction with the requirements of relevant legislation.

2.1.1 Construction wiring

Construction wiring shall be supplied from-

(a) an electricity distributor's main.

(b) an existing switchboard in the permanent installation of the premises;

(c) a low voltage generating set complying with and installed in accordance with AS/NZS 30 IO; or

(d) an inverter complying with the requirements of AS/NZS 4763.

2.1.2 Appliances, luminaires and electrical equipment

All appliances, luminaires and other electrical equipment shall be supplied from-

(a) a final sub-circuit of the construction wiring, provided with overcurrent protection in accordance with Clause 2.4.5.2 and additional protection in accordance with Clause 2.4.6.1;

(b) permanent wiring, provided with additional protection in accordance with Clause 2.4.6.2; or

(c) a stand-alone power source, provided, where necessary, with additional protection in accordance with Clause 2.4.6.3 or Clause 2.4.6.4, as applicable.

2.1.5 Polarisation

All plugs, fixed socket-outlets and cord extension sockets of single and multiphase shall be connected so the polarity of the single phase complies with the requirements of AS/NZS 3000. The phase sequence of multiphase shall be the same for all fixed socket- outlets and cord extension sets on a construction or demolition site.

2.1.6 Separate circuit requirements

One or more separate circuits shall be provided for each of the following specific types of electrical equipment:

(a) Socket-outlets.

(b) Lighting points.

(c) Permanently connected welding equipment.

(d) Other specific electrical equipment as required by AS/NZS 3000.

(e) Transportable structures (see also Clause 2.9 and AS/NZS 3001).

(f) Auxiliary socket-outlet panels.

2.2 MAXIMUM DEMAND

The maximum demand of mains and sub-mains of construction wiring shall be determined by one of the methods specified in AS/NZS 3000.

2.3 SWITCHBOARDS INSTALLED FOR THE PURPOSE OF CONSTRUCTION AND DEMOLITION

2.3.1 Location

2.3.1.1 General

All switchboards shall be installed in accordance with AS/NZS 3000.

All switchboards shall be readily accessible and protected from damage during the course of the construction or demolition work.
Every switchboard or part of a switchboard that is supplied from a separate source of supply shall be legibly and indelibly marked to identify the source of supply from which it originates.
NOTE: If the source of supply is a generating set, a unique identifier such as the plant number of the generating set satisfies this requirement.

2.3.2 Switchboard construction

2.3.2.1 General requirements

All switchboards, including those described in Clause 2.3.2.2, shall be constructed to comply with the following requirements:

(a) Robust construction and materials to withstand mechanical damage from environment or other external influences that may be expected at the location.

(b) The enclosure shall have a degree of protection appropriate for the environment in which it is installed subject to a minimum degree of protection oflP23.

(c) Live parts shall be effectively protected at all times against contact by personnel operating equipment located on the switchboard, including the connection or disconnection of plugs to socket-outlets.

(d) Where the switchboard is provided with a socket-outlet, means to prevent strain at connections or terminations, such as an insulated or covered tie bar, shall be provided for the anchorage of external cables and flexible cords.

(e) Where provided with a door or lid to maintain a degree of protection, the door or lid shall-

- (i) require the use of a tool for removal;
- (ii) be fitted with a facility for locking;
- (iii) be fitted with a means of retention in the open position;
- (iv) not damage leads and allow the safe entry of leads if the switchboard 1s provided with socket-outlets;
- (v) display a clearly visible and legible sign fixed on the external surface, e.g. words to the effect of 'KEEP CLOSED-RUN ALL LEADS THROUGH BOTTOM'; and
- (vi) be kept closed except when access is required.

(f) Where there is more than one switchboard on the site, marking shall be provided, by means of numbers, letters or both, to distinguish one switchboard from another.

(g) Switchboards shall be marked in accordance with Appendix C to indicate the presence of live parts.

NOTE: Some regulatory jurisdictions require provision to be made on construction and demolition switchboards supplying more than one final sub-circuit, for the fitting of a lockable or sealable cover over circuit-breakers and RCDs associated with these circuits or other devices that would control the resetting of circuit-breakers and RCDs but does not prevent access to isolation switches.

2.3.3 Mounting of switchboards

Switchboards shall be securely attached to a pole, post, wall, floor or other structure of a stable, freestanding design that takes into account any external forces that may be exerted on the switchboard, e.g. by flexible cords.

2.3.4 Socket-outlets

Socket-outlets provided on switchboards for the connection of portable appliances and other electrical equipment shall be rated at not less than 10 A.

NOTE: Where required al[switchboards should be fitted with at least one l 5 A or one 16 A, single phase, socket-outlet. For example, such socket-outlets may be required to supply welders and floor sanders.

2.3.5 Support of cables entering switchboards

At each switchboard, a fixed secure and stable means shall be provided to prevent mechanical damage to flexible cords and cables and prevent the transfer of mechanical strain to the cable connections (see Clause 2.5.3).

NOTE: An example of such a means is to support flexible cords and cables above the floor or ground on stands, cross-arms or similar, covered with material that is non-conducting.

2.4 CONTROL AND PROTECTION

2.4.1 Control

Each switchboard shall be provided with one isolating switch marked in accordance with Clause 2.4.3 and complying with the requirements for isolating switches in AS/NZS 3000. This switch shall interrupt supply to all final sub-circuits and sub-mains originating from the switchboard, including circuits supplying socket-outlets mounted on the switchboard.

2.4.2 Securing of isolating switch

Isolating switches shall be provided with a means to prevent electrical equipment from being inadvertently energized. The means of isolation shall be such that a deliberate action in addition to the normal method of operation is required to energize the circuit.
One of the following methods shall be regarded to satisfy this requirement:

(a) Provision for the fitting of a padlock.
(b) Location within a lockable space or enclosure.

2.4.3 Marking of isolating switches

All isolating switches controlling the portions of the installation included in Clause 2.4. l shall be marked in accordance with AS/NZS 3000 and as follows:

(a) 'MAIN SWITCH'-on main switchboards.

(b) 'DISTRIBUTION BOARD ISOLATING SWITCH'-on distribution boards.

(c) 'ISOLATING SWITCH AFTER HOURS SUPPLY-DO NOT SWITCH OFF'-for circuits supplying electrical equipment operating out of normal working hours. Main switches for safety services shall be identified in accordance with AS/NZS 3000.

2.4.4 Size of marking

Letters used for marking in accordance with Clause 2.4.3 shall not be less than 6 mm high and of a contrasting colour to the background material.

2.4.6 Additional protection-Basic protection and fault protection

2.4.6.1 Final sub-circuits of construction wiring

All final sub-circuits of construction wiring shall be protected at the switchboard where the final sub-circuits originate by residual current devices, with a maximum rated residual current of 30 mA, which operate in all live (active and neutral) conductors. The final sub-circuits shall be arranged-

(a) where the number of RCDs installed exceeds one; and

(b) where more than one lighting circuit is installed. The lighting circuits shall be distributed between RCDs.

NOTE: This arrangement is intended to minimize the impact of the operation of a single RCD.

Exceptions: Additional protection by an RCD need not apply to any of the following types of final sub-circuit:

1 Final sub-circuits supplying electrical equipment where safe mechanical operation is at risk, e.g. electric cranes or personnel lifts.

2 Final sub-circuits where all appliances, luminaires and other electrical equipment are supplied from a directly connected SELV or PELV source in accordance with the requirements of AS/NZS 3000 for extra low-voltage supply.

3 Final sub-circuits where all appliances, luminaires and other electrical equipment are supplied from a directly connected safety isolating transformer complying with AS/NZS 61558.2.23, supplying a separated circuit for electrical equipment installed in accordance with the electrical separation requirements of AS/NZS 3000 and with each winding supplying not more than one item of Class I (earthed conductive parts) electrical equipment.

NOTE: This description includes a single winding supplying one or more items of Class II (double insulated) electrical equipment and a single winding supplying one item of Class I (earthed conductive parts) electrical equipment plus one or more items of Class JI (double insulated) electrical equipment.

4 In New Zealand only, A 110 V centre-tapped transformer to the requirements of AS/NZS 61558.2.23 providing a reduced low voltage source of supply, and circuits connected to the transformer shall be fitted with plugs and sockets that are not interchangeable with other systems of supply (refer to AS/NZS 3000).

2.4.7 Switching of single-phase socket-outlets

Every single-phase socket-outlet in the following situations shall be individually controlled by a switch operating in all live (active and neutral) conductors:

(a) Portable generators of the isolated winding type fitted with integral socket-outlets.
(b) Portable inverters of the isolated type fitted with socket-outlets.
(c) Portable socket-outlet assemblies.
(d) In Australia only, on or in transportable structures that are connected to supply by a0 flexible cord and plug.
(e) Socket-outlets on equipment that is supplied by means of a plug and socket.

NOTE: Socket-outlets may be either the type with a manual switch or an integral switch that switches on when the plug top is inserted and switches off when it is removed.

2.5 CONSTRUCTION WIRING

2.5.1 Cables and fittings

Cables and fittings used in construction wiring shall comply with the requirements of AS/NZS 3000.

NOTE: The requirements of AS/NZS 2802 apply to trailing cables used for surface wiring.

2.5.2 Installation of cables

Cables shall be installed in accordance with AS/NZS 3000 except as modified in Clauses 2.5.3 to 2.5.8 below. Construction wiring shall not be-

(a) tied, bundled or grouped with permanent wiring; nor

(b) attached to free-standing fencing.

2.6 FLEXIBLE CORDS, CORD EXTENSION SETS, FLEXIBLE CABLES AND ACCESSORIES

2.6.1 General

Clause 2.6 applies to the following:

(a) Flexible cords.

Exception: This Clause does not apply to flexible cords that are-

(i) permanently attached to electrical equipment; or
(ii) 5 m or less in length.

(b) Cord extension sets.
(c) Flexible cables.
(d) Accessories used to connect electrical equipment to switchboards.

Cord extension sets shall comply with AS/NZS 3199 except as modified by Clauses 2.6.2 to 2.6.9. All cords shall be wired identically.

2.6.3 Type of flexible cord and cable

Flexible cords used in cord extension sets shall be heavy-duty and sheathed. The flexible cord shall comply with AS/NZS 3191. Flexible cable shall comply with the AS/NZS 5000 series.

2.6.12 Electrical portable outlet devices {EPODS)

Electrical portable outlet devices in accordance with AS/NZS 3105 (e.g. domestic type power boards) do not comply with the requirements of Clause 2.6. 10 or Clause 2.6.11 and shall not be used on construction and demolition sites.

2.7 LIGHTING AND LUMINAIRES

2.7.1 General lighting

Minimum lighting levels should be 40 Ix for walkways and 160 Ix for general areas.

2.7.2 Mechanical protection

Lamps in luminaires shall be protected against mechanical damage.

2.7.3 Emergency lighting

2.7.3.1 General

Emergency lighting shall be provided in designated access and egress paths and directly above and in front of switchboards, on all demolition and construction sites where the general lighting requirements cannot be met using natural lighting. Such lighting shall allow safe access to and egress from the site.

2.7.4 Hand-held luminaires

Hand-held luminaires shall comply with AS/NZS 60598.2.8.

2.7.5 Edison screw type lamp holders

Where a neutral conductor is required for the connection of an Edison screw lamp holder, that neutral conductor shall be connected to the outer contact.

2.7.7 Portable luminaires

Portable luminaires shall be provided with the following:

(a) A minimum degree of protection IP2X in accordance with AS 60529.

(b) A mechanical guard for the lamp.

(c) Adequate stability.

2.8 LIFT SHAFTS

2.8.1 General

Construction wiring dedicated to the installation of lift shaft equipment shall consist of a separate final sub-circuit protected in accordance with Clause 2.4.6.1.

Circuit breakers shall be locked and tagged to prevent inadvertent isolation of supply to the lift shaft by others on the site.

Lift shaft lighting shall be supplied from either construction wiring or permanent wiring and should comply with the following minimum requirements:

Luminaires should be-

(a) at a minimum lighting level equivalent to that provided by a 36 W fluorescent and guarded against mechanical damage;

(b) connected to supply via a plug and socket arrangement; and

(c) installed at intervals not exceeding 6m with the uppermost fixture installed within 1m of the top of the lift shaft.

3.1 APPLICATION

This Section describes the verification (i.e. assessment, inspection and testing) procedures and frequency to be followed on all components of the electrical installations of construction and demolition sites. It applies to-

(a) construction wiring;

(b) switchboards;

(c) RCDs and RCD type;

(d) transportable structures;

(e) the connection between generator windings and the equipotential bonding system on generators fitted with an RCD;

(f) the connection between the frame and the equipotential bonding system of an isolated winding generator;

(g) inverters; and

(h) any other electrical equipment used on construction and demolition sites.

3.7 ACTIONS RESULTING FROM INSPECTION AND TEST

3.7.1 Construction wiring

Where a visual inspection identifies damage or non-compliance with this Standard, that pa1t of the installation shall be isolated, repaired or replaced and tested as required.

3.7.2 Non-compliant equipment

Where inspection or testing identifies equipment that fails to comply with the criteria given

in this Standard, the equipment shall be-

(a) withdrawn from service immediately, have an out-of-service tag attached to it warning against further use; and

(b) sent for repair, disposal or destruction by an authorized repair agent or service personnel.

3.7.3 Compliant equipment

New equipment, after inspection and tests, shall be fitted with a durable, non-reusable, non-metallic tag. Construction wiring, switchboards, fixed RCDs, fixed and transportable electrical equipment need not be tagged.

Following periodic verification, compliant equipment shall be re-tagged. The items covered in Clause 3.3.2 need not be tagged.

The tag, which may be colour coded to identify the period in which the test was performed, shall include the-

(a) name of the person who performed the tests; and

(b) test and re-test dates.

NOTE: Appendix D gives a recommended colour coding schedule for tags on compliant equipment.

APPENDIX C

MARKING OF SWITCHBOARDS TO INDICATE THE PRESENCE OF LIVE PARTS

(Normative)

Where access to live parts is required, a symbolic electric shock risk sign (see Figure C1) shall be displayed in locations where additional attention is required in the removal of covers, e.g. covers for switchboards or cable junctions.

FIGURE C1 ELECTRIC SHOCK RISK SIGN

In addition, a danger sign with an additional message (see Figure C2), e.g. indicating the presence of live parts within, shall be conspicuously displayed on the enclosure of the ASSEMBLY to alert personnel to the hazard.

FIGURE C2 DANGER SIGN WITH SPACE FOR ADDITIONAL MESSAGE

APPENDIX D

RECOMMENDED COLOURS FOR TAGS ON TESTED EQUIPMENT

(Informative)

This Appendix gives a recommended colour coding schedule for tags on tested equipment. The tag should indicate by its colour the period in which the test was performed in accordance with the following schedule:

(a) Red December-February.

(b) Green March-May.

(c) Blue June-August.

(d) Yellow September-November.

NOTES:

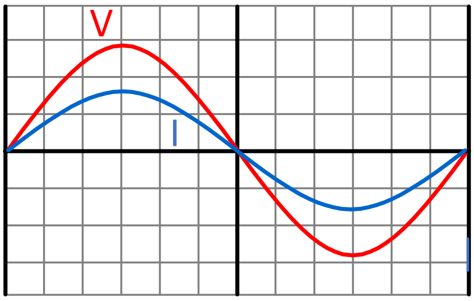
1. Some construction sites will not allow the use of equipment on site unless the tag colour readily indicates the required retest date in accordance with Table 6.
2. The colours shown above apply to 3-month requirements.

Activity 16

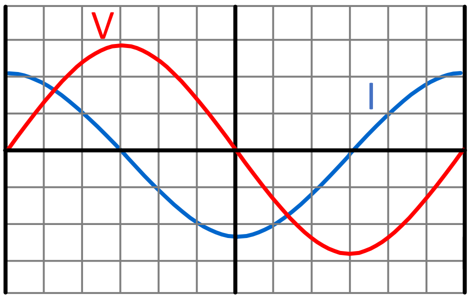
Answers found also in the definitions

Waveforms

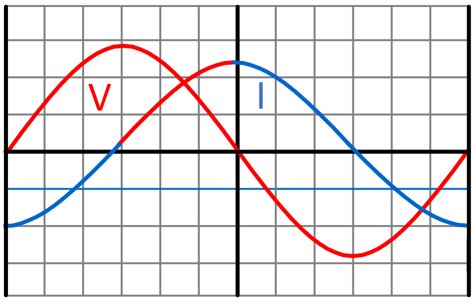
In-phase



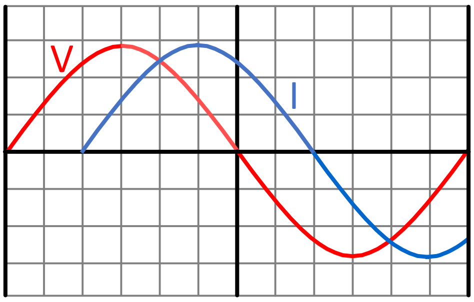
Out-of-phase – current leading the voltage



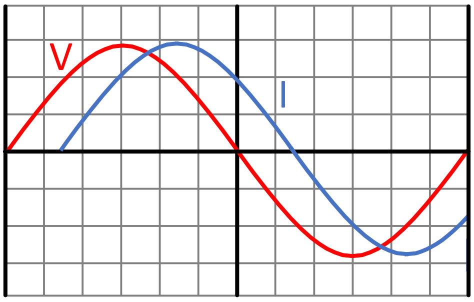
Out-of-phase - current lagging the voltage



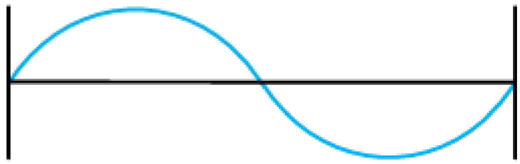
Phase difference of 60°



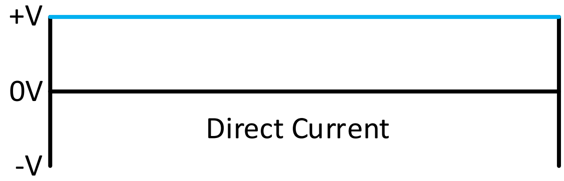
Phase difference of 45°



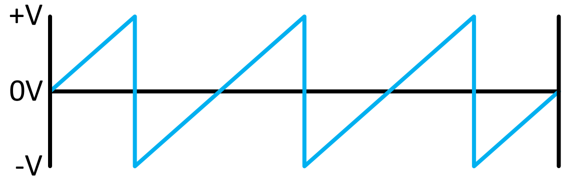
Waveforms (cont.)



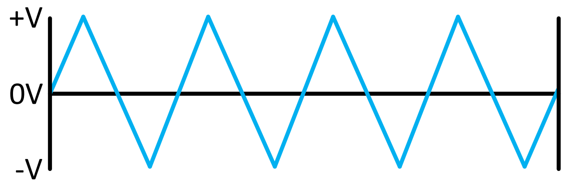
Sinusoidal



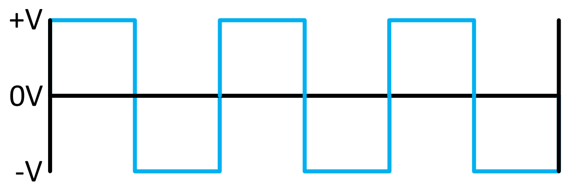
Direct Current



Sawtooth

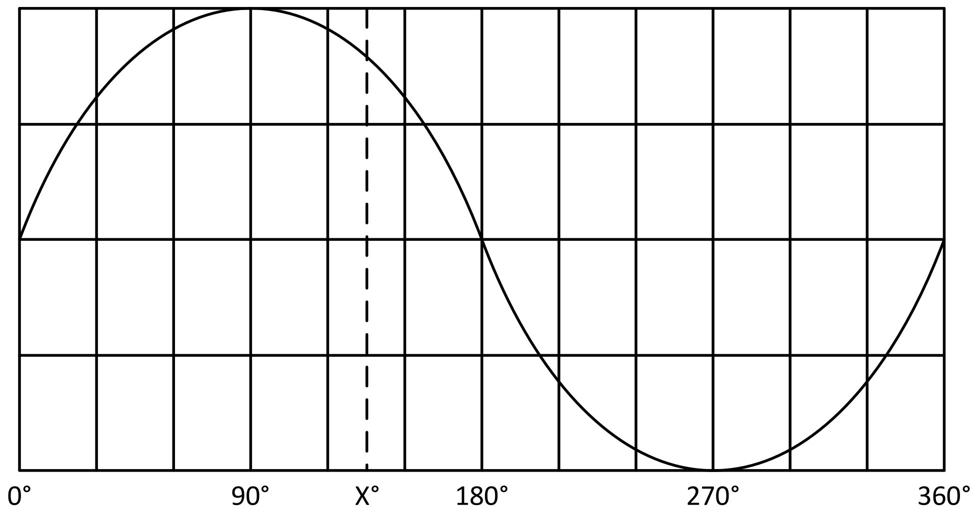


Trianglular



Square

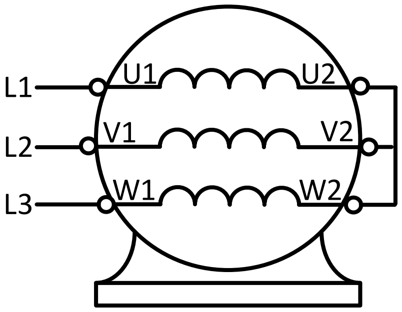
360° Waveform

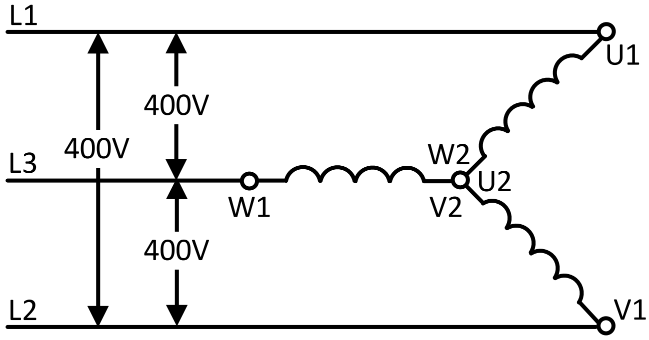


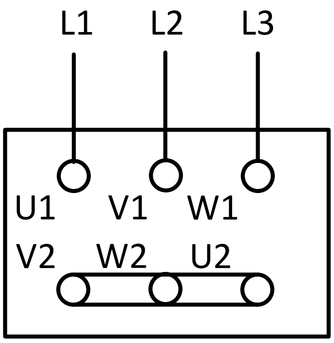
Three Phase

Star and Delta – motor connections

Star



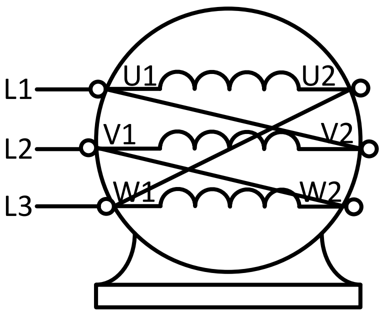


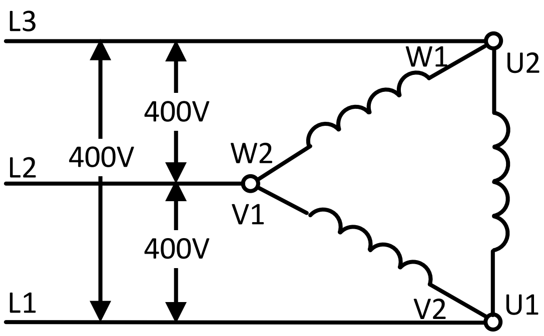


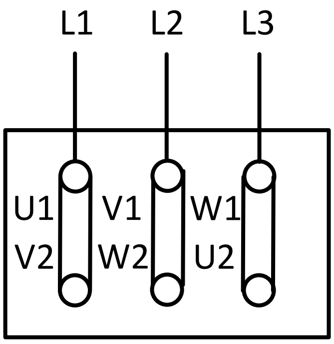
Star

$I_L = I_P$
$V_L = \sqrt{3}\ x\ V_P$

Delta







Delta

$V_L = V_P$
$I_L = \sqrt{3}\ x\ I_P$

Activity 17

Induction Motor Enclosures

Induction motors come in a range of different enclosures and where it is installed will determine the type of enclosure.

The term enclosure refers to the casing of the motor.

Induction motor enclosures will protect the windings, bearings, and other mechanical parts from moisture, mechanical damage and the environment.

Common types of enclosures (not all enclosures are mentioned below) are.

1) Open Drip Proof (ODP)
This type allows air to circulate through the motor via vents but prevents solids and liquids from falling into the motor that can damaging the windings of motor.

This type of enclosure is typically installed indoors where the environment is clean and dry.

2) Totally Enclosed Fan Cooled (TEFC)

This type is designed to block the air between the outside of the frame and the inside of the motor to mix, however, this does not make it fully airtight.

The motor could have moisture, dust enter the inside of motor through the seal of the shaft.

A fan attached to the shaft blows air over the frame during its operation which helps to keep the motor temperature stable.

This type is suitable for industrial and domestic application. indoor or outdoor use.

3) Totally Enclosed Non-Ventilated (TENV)

This type is similar to the TEFC type except it doesn't have an external fan mounted on the end drive of the motor.

The motor relies on convection for cooling.

4) Totally Enclosed Air Over (TEAO)

This type has an external fan mounted at the end drive of motor.

The fan blows air over the exterior of the motor to discharge heat more quickly.

The fan is covered by a shroud, or the motor is installed in an out of reach location for safety reasons.

This type is suitable for corrosive, dirty or moist surrounding areas.

5) Explosion Proof (XPRF)

This type of motor is totally enclosed and can withstand gases or vapours which could cause an explosion, from entering the motor to prevent the motor from causing an explosion outside the motor

These motors can be made from cast iron material to withstand hazardous impacts.

The motor is normally installed in highly flammable or hazardous areas e.g. oil & gas, petrochemical or chemical industry.

Explosion proof motors (installed in hazardous areas) cost quite a bit more than a conventional induction motor.

Activity 18 Answers found in AS/NZS 3000 & AS/NZS 3008.1.1

Activity 19 Answers found in AS/NZS 3000

Activity 20 Answers found in AS/NZS 3000

Activity 21 Answers found in AS/NZS 3000

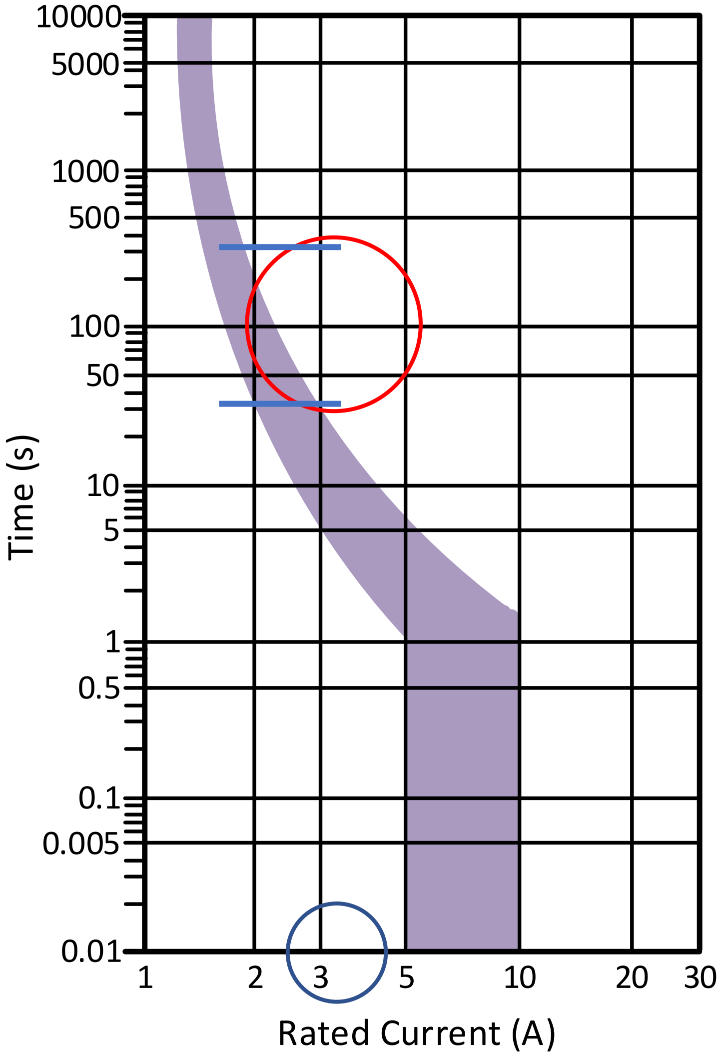
Activity 22 Answers also found in AS/NZS 3000

How to Interpret Characteristic Curves

A circuit breaker and fuse protects cabling from over-current, which has overloaded or short circuited, and must trip within a certain time.

AS/NZS 3000, clause number 1.5.5.3, states that a protective device must disconnect the supply voltage, 230/400V, within:

- 0.4 seconds for:
  - socket-outlets not exceeding 63A,
  - hand-held Class I equipment, or
  - portable equipment used for manual movement.
- 5 seconds for other circuits including submains and final subcircuits.

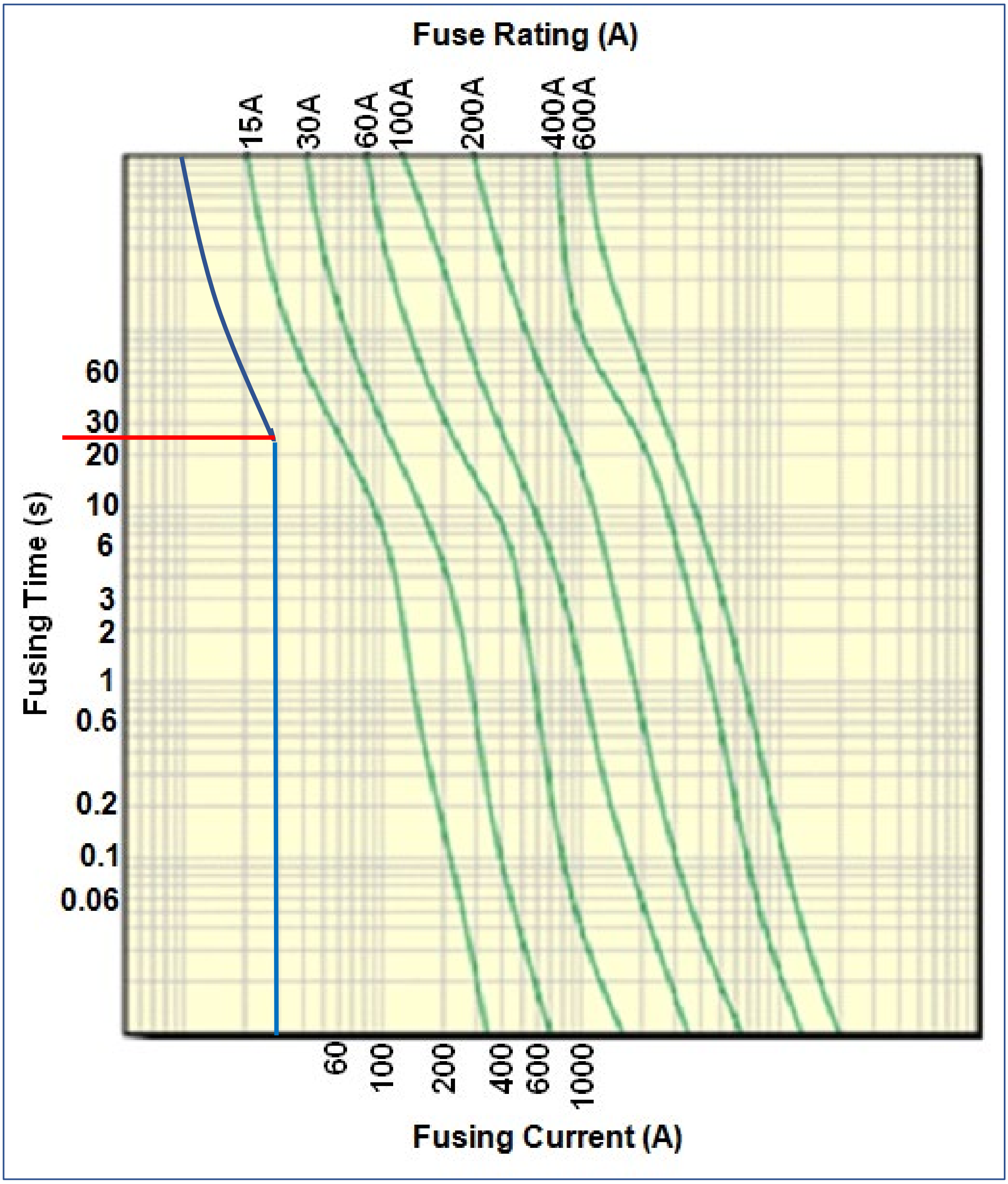


Time-current characteristic curve for a circuit breaker

What is the trip time for a 16A circuit if the current increased to 32A?
Use the formula below to answer the question.

$$\frac{\text{Ia}}{\text{I}_{\text{N}}} = \frac{32}{16} = 2 \text{ (indicated by the blue circle)}$$

Trip time is approximately between 30 seconds and 130 seconds (indicated by the red circle and two blue lines).



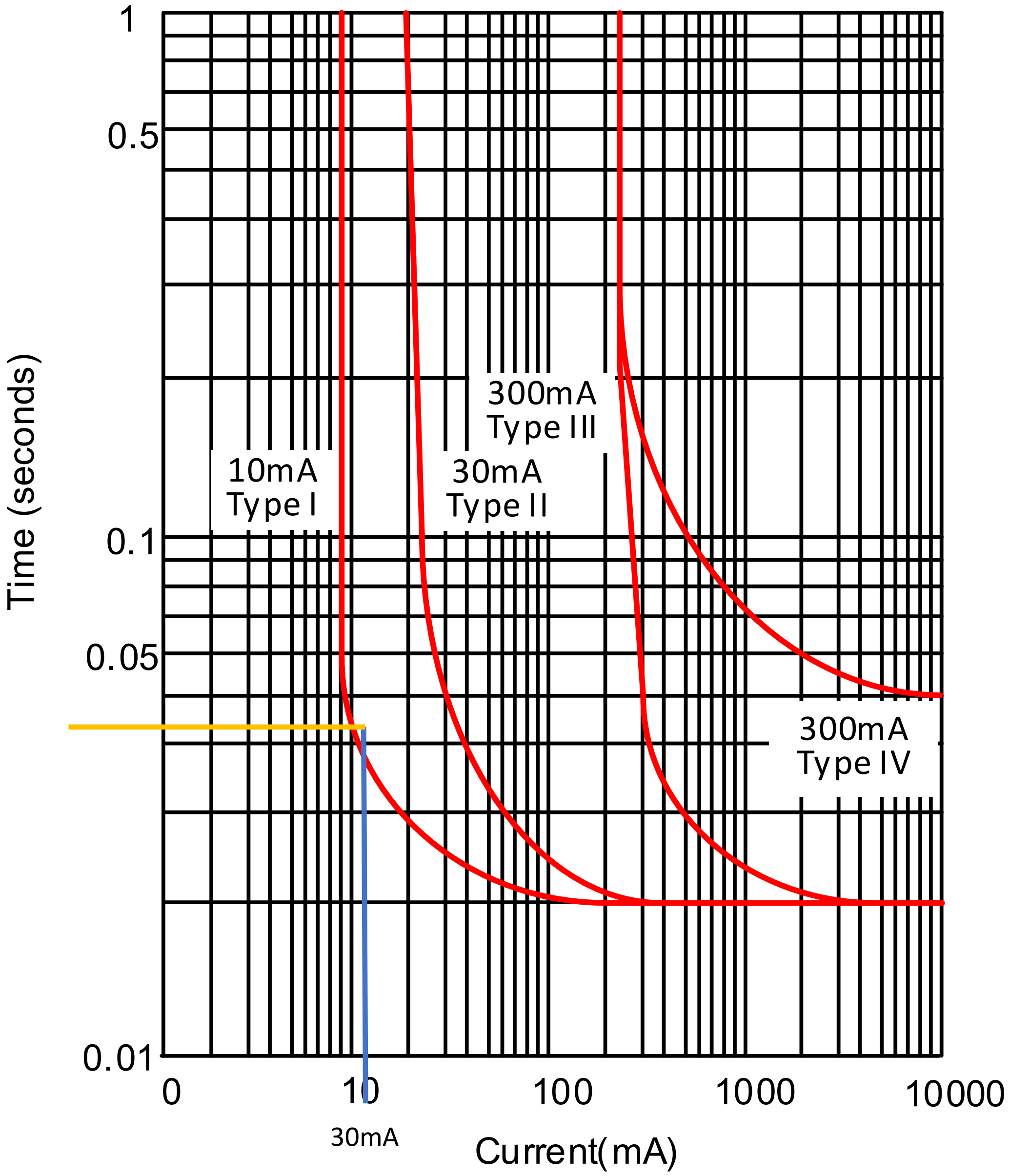
Time-current characteristic curve for a fuse (HRC)

What is the trip time for a [1]15A motor-rated HRC fuse if the current increased to [2]60A?

To answer the question:

1. go to the top of the diagram, fuse rating (A), and locate the 15A line[1.]
2. go to the bottom of the diagram, fuse current (A), and locate 60 (60A)[2].
3. trace the 15A line down the diagram (blue line)
4. Trace the 60A line up the diagram (blue line).
5. Where the two lines meet is the answer (red line).

Answer = approximately 25 seconds



Time-current characteristic curve for a RCD

There are four types of RCD, type I to IV.

Types I and II are used to protect people and animals from electrocution. They range from 10mA to 30mA with different trip times.

Types III and IV are used where nuisance tripping could be a problem.

- Type I RCDs are rated ≤10mA
- Type II RCDS are rated >10mA and ≤30mA
- Type III RCDs are rated >30mA and ≤300mA
- Type IV RCDs are rated >30mA and ≤2000mA

To determine tripping time

- locate the 30mA line
- locate 30mA (bottom line of graph)
- trace the 30mA line up the graph until it intercepts the 30mA line (blue line)
- where it intercepts the 30mA line, take a line across to the time (seconds) axis (orange line)

Answer = expected tripping time 0.04seconds or 4mS.

Activity 23

Excerpt from the WA Electrical Requirements

https://www.commerce.wa.gov.au/publications/wa-electrical-requirements-waer

WA Electrical Requirements

1. Introduction

The WAER applies to all electrical installations, whether connected to distribution networks, transmission networks or stand-alone ('off-grid'), with operating voltages up to 330kV.

Nothing in this document may be used or interpreted to vary any of the requirements for a consumer installation specified in any of the Australian Standards prescribed in Section 9, unless:
(a) details of such variation(s) are set out in this document; or
(b) the relevant Standard has a specific provision for varying the prescribed requirements (for the matter in question), at the discretion of the network operator.

The WAER sets out minimum requirements for all electrical installations in WA.

Network operators may prescribe additional or enhanced requirements as a condition of connection to their networks.

2. Definitions

- Consumer: Any person to whom electricity is supplied.
- Consumer pole: A private pole required to provide ground clearance for the network operator's overhead service cables (refer Figure 3.1 [b]).
- Consumers mains: Those conductors between the point of supply and the consumer's main switchboard.
- High voltage: Voltages exceeding 1000 Volts a.c.
- Load: The total maximum electrical power demanded by a consumer's installation, measured in amperes or watts. This is the maximum demand defined and calculated according to the Wiring Rules.
- Point of attachment: The point at which an aerial service cable is physically secured on a consumer's structure.
- WASIR: Western Australia Service and Installation Requirements as published by Western Power and Horizon Power
- Wiring Rules: AS/NZS 3000 as published by Standards Australia.

3. General Requirements

3.1 Supply Arrangements

Supply arrangements for consumers shall comply with this document and other statutory requirements.

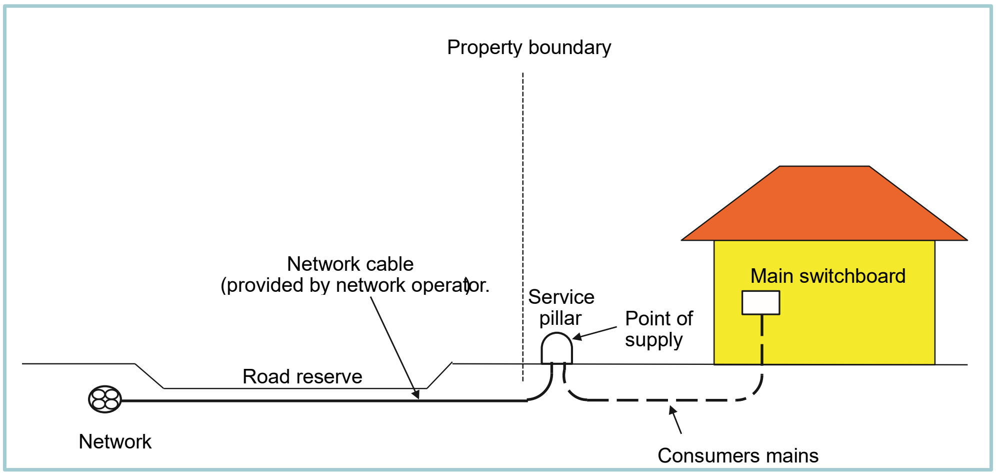


Figure 3.6 Underground network and underground consumers mains

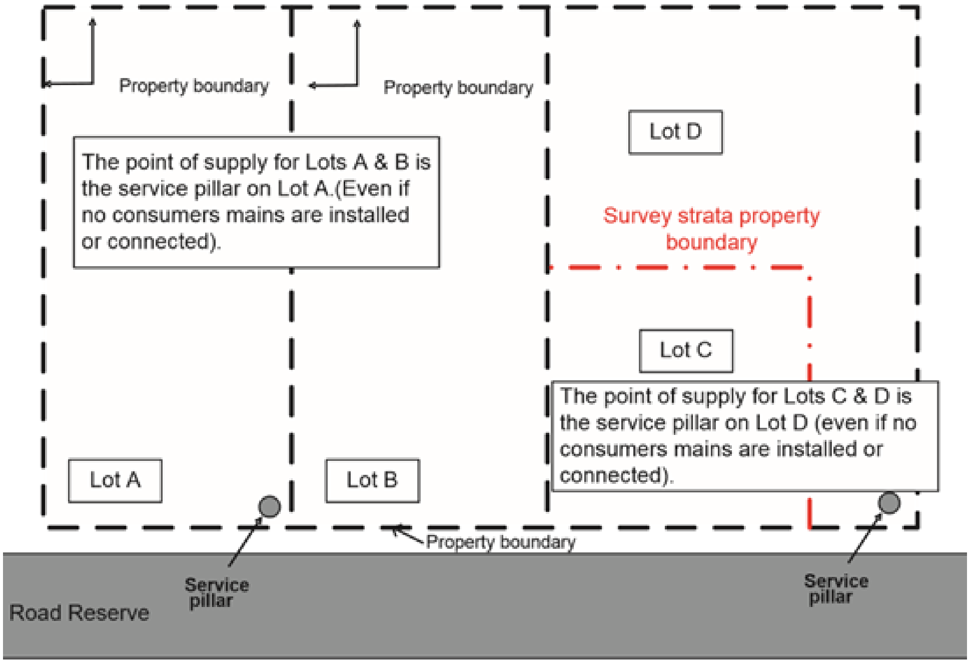


Figure 3.8(a) Example of points of supply

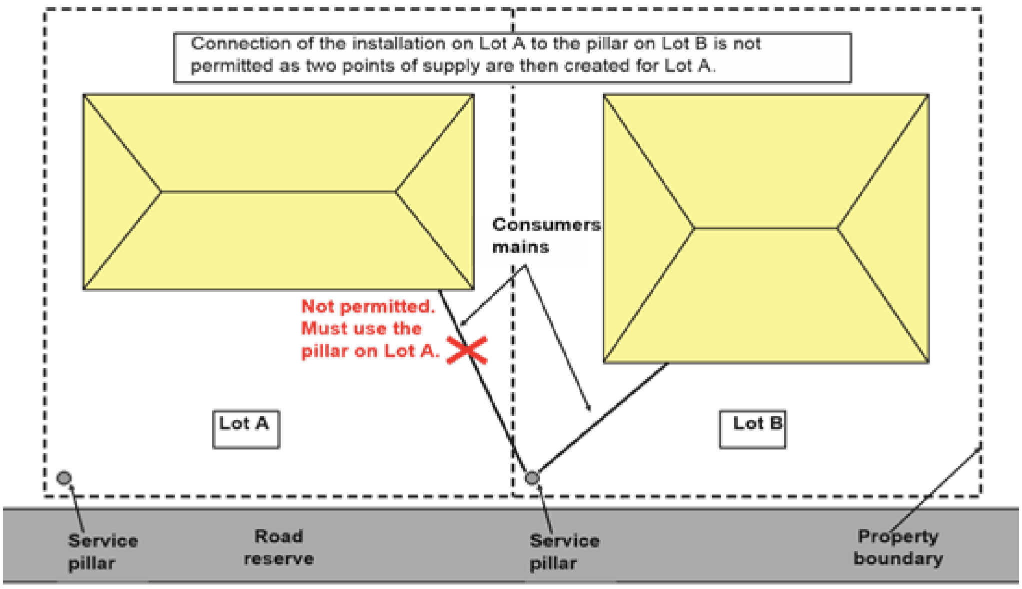


Figure 3.8(b) Example of points of supply

3.5.9 Temporary Builder's Supplies

The following are the minimum requirements for provision of a temporary builder's supply to a lot with an existing point of supply:

- Temporary building supplies shall comply with the Wiring Rules. AS/NZS 3012, Electrical installations – Construction and demolition sites also is required where relevant.
- The builder shall be responsible for both the permanent and the temporary supplies while the building site is under the builder's care.
- The temporary builder's supply shall service only the building project site and all wires and cables energised from this supply shall be within the builder's operational area, fenced or not.
- Where building work takes place on an adjacent block, the network operator may provide separate temporary builder's supplies.

Network operator connection requirements may also contain relevant additional criteria.

4. Low Voltage Overhead Connections

4.1 Connection

Network operators shall determine the method of connection in areas serviced by an overhead distribution network.

4.5 Consumer poles

Property owners may be required to supply and install a pole on their property to ensure that:

- aerial ground clearances above both trafficable areas and property comply with the Wiring Rules;
- aerial spans do not exceed acceptable limits, and
- aerial spans do not pass too close to pools, spas and other buildings.

The design and installation of consumer poles shall comply with the technical requirements of the respective network operator.

A network operator may elect to supply and install the consumer poles on behalf of the property owner in certain cases, but the property owner remains responsible for the continuing maintenance of such poles after installation, including their replacement when required.

5. Low Voltage Underground Connections

5.1 Connection

The network operator shall determine the method of connection in areas serviced by an underground distribution system.

Special arrangements may apply to consumer's installations supplied at high voltage or from multiple transformers. Reference should be made to the relevant network operator requirements for connection to their networks, such as the WASIR for Western Power or Horizon Power.

6. Metering and Service Equipment

6.1 General

Network operators shall determine the type and location of consumer connection arrangements, metering and service equipment, which must comply with the network operator's connection requirements. Where an existing network connection or metering arrangement is altered it shall be classified as a new connection which must comply with all relevant standards and the network operator's connection requirements.

Connection of generation and storage systems (Distribute Energy Resources) to an existing connection or metering arrangement shall be classified as an alteration, requiring consultation with the relevant network operator before proceeding.

This section provides particular requirements for low voltage installations only. For high voltage installations, further details shall be obtained from the relevant network operator.

7. High Voltage Installations

7.1 General Requirements

Consumer high voltage electrical installations must be designed, constructed, maintained and operated by competent persons, consistent with good industry practice, to ensure the safety of consumers, workers, equipment, private, public and network operator property and the general public.

The fundamental requirements specified in Regulations 49, 49A and 49B of the Electricity (Licensing) Regulations 1991 and Chapter 9 of this document must be observed.

The technical requirements for the design of HV installations are contained in various technical standards which include, but are not limited to:

- AS/NZS 2067;
- AS/NZS 3000, the Wiring Rules;
- AS/NZ 7000; and
- network operator connection requirements.

Network operators may also have additional requirements applicable for specific locations and to the large-scale installations listed above.

A consumer's large-scale installation commences at the point of supply as designated by the network operator (where connection to a network is sought) and/or at the output terminals of on-site generating plant.

The large-scale installations listed above located on mine sites are also required to comply with mines safety inspection legislation administered by the Department of Mines, Industry Regulation and Safety.

8. Emergency Conditions

8.1 Emergency Disconnection

Under emergency conditions, electrical contractors may open the SPD or otherwise isolate the installation from the low voltage electricity supply to ensure their own, occupants' and the public's safety.

Electrical contractors also may remove the SPD fuse cartridge or operate the SPD circuit breaker to achieve isolation before commencing electrical work on the consumer's installation, including the main switchboard. Contractors may be required to inform the relevant network operator before doing so and again when re-energising the installation.

Electrical contractors and their employed electricians shall exercise care:

- not to isolate unnecessarily any emergency equipment such as fire- fighting services or evacuation aids; and
- to ensure that all other supply sources are isolated, including energy generation/storage systems before any electrical work is commenced.

9 Special Requirements for Installations in WA

Under Regulation 49 of the Electricity (Licensing) Regulations 1991, the requirements set out below, which are additional to or at variance with the Wiring Rules and other Australian Standards, are mandatory and take precedence over those appearing in the Australian Standards.

9.1 Application of Wiring Rules Part 1

Electrical installation designers choosing to use a Wiring Rules Part 1 design and installation solution (rather than apply the deemed to comply requirements of Part 2) must comply with section 1.9.4 of the Wiring Rules and the following additional requirements.

Designers must not adopt a Part 1 solution for the following types of electrical installations, which must comply with Part 2 of the Wiring Rules and the applicable standard or standards referred to in Section 9.12:

- domestic installations,
- construction and demolition sites,
- medical treatment areas,
- relocatable installations and the site installations to supply them,
- marinas and pleasure craft, and
- shows and carnivals.

Design Work

Designers must be competent to carry out designs that depart from Part 2 of the Wiring Rules under the provisions of section 1.9.4.1. For the purposes of this requirement, the following persons may be considered competent:

- Currently licensed electricians with at least 10 years' experience in the design and construction of consumer's electrical installations (other than domestic installations) since qualifying, including not less than 5 years design experience in total.
- Electrical designers holding a TAFE Advanced Diploma in Electrical Engineering (or equivalent) and have at least 5 years' experience in the design of consumer electrical installations (other than domestic installations).
- Professionally qualified engineers.

The designer must establish and retain for at least 10 years a folder that contains:

- the document referred to in Clause 1.9.4.2 of the Wiring Rules, which contains the installation owner's or operator's acknowledgment and acceptance that some parts of the installation do not conform to Part 2 of the Wiring Rules; and
- the specific information listed in Clause 1.9.4.3 'Documentation' of the Wiring Rules.

The designer is also required to provide one copy of the folder and contents to the responsible person for the installation, and a further copy to the person engaged to verify the compliance of the installation.

The designer shall make his/her folder available for examination by an Inspector (Electricity), if requested.

Additionally, the designer shall complete Section A of the 'Part 1 Design and Verification Certificate' (appended to this document).

Verification of Compliance

Both the design and construction of the parts of the installation that do not comply with Part 2 of the Wiring Rules are required to be independently assessed to confirm compliance with the requirements listed in Wiring Rules Clause 1.9.4.1 paragraphs (a), (b) and (c), as required by Clause 1.9.4.4.

This verification assessment work may only be carried out by persons who:

- were not involved in the design of the installation; and
- do not report to the designer (i.e. They may be part of the same organisation, subject to these constraints); and who are one of the following:
  - Currently licensed electricians with at least 10 years' experience in the design and construction of consumer electrical installations (other than domestic installations) since qualifying, including not less than 5 years design experience in total.
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On completion of the verification assessment, the verifier may, if satisfied, complete Section B of the 'Part 1 Design and Verification Certificate' appended to this document.

It is the designer's responsibility to ensure the verification work is carried out.

When completed by both the designer and verifier, the certificate must be placed with the project folder referred to above and retained by the designer for at least 10 years. A copy of the certificate shall be provided to the network operator on request.

9.2 Consumers Mains

9.2.1 Design

Single and multi-phase consumers mains shall have a minimum current-carrying capacity of 32A per phase, except for:

- single domestic installations, where the minimum current-carrying capacity shall be:
  - Single-phase: 63A,
  - Multi-phase: 32A per phase and
- multiple installations which incorporate a domestic installation, where the minimum current carrying capacity shall be:
  - Single-phase: 63A,
  - Multi-phase: 63A per phase.

The cable sizes used for consumers mains to domestic premises shall be no less than:

- single-phase: 10 square millimetres, copper conductors, or
- three-phase: 6 square millimetres, copper conductors.

When calculating voltage drop in an installation, the component of voltage drop across the consumers mains shall be assessed using the maximum demand of the installation or 80% of the minimum current carrying capacity specified above, whichever is the greater. The maximum length permitted for consumer mains is 30 metres, where voltage drop may determine the necessary cable size.

Installation designers should bear in mind the steadily growing demand maxima imposed by domestic dwellings, especially with the increasing popularity of air conditioning and possible electric vehicle charging.

To allow for demand growth, and the possibility of all-electric homes, designers and contractors should consider installing 16 and 10 square millimetre copper conductors respectively for single-phase and three-phase consumers mains.

9.5 Protection of PV Array DC cables

Insulated and sheathed d.c. cables may be installed in the cavity of double-brick walls without enclosure in heavy duty conduit (reference Clause 4.3.6.3.2 of AS/NZS 5033) but shall otherwise comply with the requirements of that standard. Such cables installed within brick veneer shall be mechanically protected by heavy duty conduit.

9.6 Equipotential bonding in shower recesses and bathrooms

Equipotential bonding of the conducting metal reinforcing mesh within concrete floors and walls forming part of a shower recess or bathroom is not required.

9.9 Reporting of unsafe electrical installations

Where an electrical worker identifies a defect in an electrical installation that renders that installation unsafe, Regulation 62 of the Electricity (Licensing) Regulations 1991 requires that person to advise the electrical contractor, who shall report the matter to the owner and the relevant network operator (or the Director).

Such defects include but are not limited to:

- unenclosed electrical joints in ceiling spaces; or
- degraded wiring insulation.

Where occurrences of unenclosed joints or degraded wiring insulation have already been rectified, no reporting is required under Regulation 62.

The fitting of an RCD, while recommended, is not acceptable (on its own) as an effective remedial action for such defects.

9.10 Applicable standards

References are made throughout this document to relevant technical standards that apply to various aspects of electrical installations.

Electrical work must be carried out so as to comply (where applicable) with the latest version of those standards listed in Schedule 2 of the Electricity (Licensing) Regulations 1991.

The solar panels, inverters, batteries and other components comprising a solar PV installation intended for grid connection must be acceptable to the relevant network operator. They also must be approved by the Clean Energy Regulator if the installation owner wishes to qualify for Small Scale Renewable Energy Credits.

10. Network Operators

10.1 Introduction
This section lists additional requirements for connections to particular networks. These requirements include commercial and technical matters not directly related to electrical safety.

Appendix 1

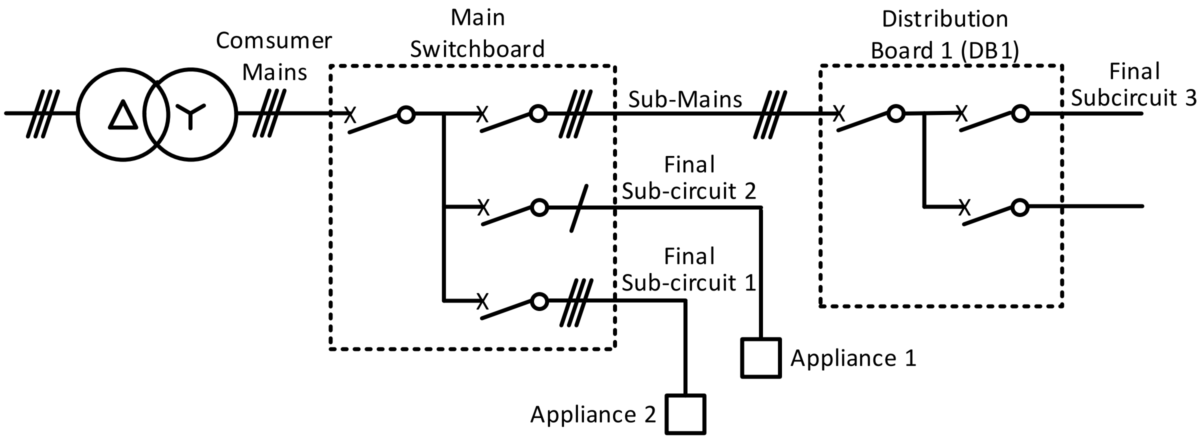
Part 1 Design and Verification Certificate.

PART 1 DESIGN AND VERIFICATION CERTIFICATE
This form has been approved by the Director of Energy Safety, Building and Energy, for use by designers and verifiers of electrical installations which are based on the Wiring Rules 'Part 1' design and installation solution, to satisfy requirements detailed in Section 9.1 of the WA Electrical Requirements (WAER) manual.

Electrical Fault Protection

Wiring Systems

Electrical wiring systems must be installed in such a way that safe working limits are not exceeded. One of the main considerations is the maximum safe current. In a typical installation such as the one outlined below, all components selected must be such that a short circuit from active to earth (i.e. a 'bolted fault') will not cause permanent damage to the installation.



If the maximum safe current in a circuit is exceeded, it can result in damage to the cable and/or associated parts of the installation.

Current Definitions

AS/NZS 3000 provides the following definitions relating to current:

- Overcurrent – A current exceeding the rated value. (Clause 1.4.90)
- Fault current – A current resulting from an insulation failure or from the bridging of insulation. (Clause 1.4.41)
- Overload Current – An overcurrent occurring in a circuit that is electrically sound. (Clause 1.4.42)
- Short-circuit Current – A fault current resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions. (Clause 1.4.43)

Protection of Wiring

The general requirements for the protection of wiring are:

(a) Small overloads of short duration should not cause the protection to operate.
(b) The protection must operate, even on a small overload, and if the overload persists long enough to cause overheating of the circuit conductors.
(c) The protection must open the circuit before damage caused by fault currents can occur.
(d) Protection must be 'discriminative' in that only the faulty circuit is isolated and other circuits remain operative and unaffected.

Overload Protection

Overload protection is achieved by opening the circuit before overheating or deterioration of the protected wiring can occur.

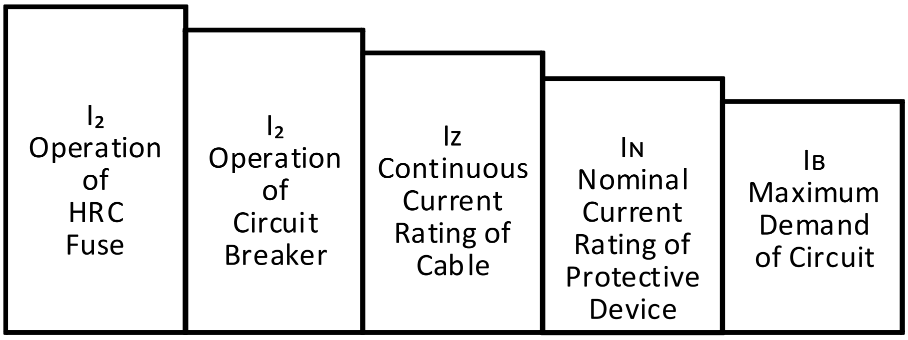
Coordination

AS/NZS 3000 Clause 2.5.3.1 requires coordination between conductors and protective devices. The operating characteristics of a device protecting a cable against overload shall satisfy the following two conditions:

- $I_B \leq I_N \leq I_z$ (The symbol ≤ means 'is less than or equal to'.)
- $I_2 \leq (1.45 \times I_Z)$

Where:

I_B = Circuit maximum demand
I_N = Nominal current of protective device
I_Z = Current carrying capacity of cable
I_2 = Current to operate protective device:
1.45 x I_N for circuit breakers or
0.9 x I_N for HRC fuses.



Short-Circuit Protection

Short-circuit fault protection is achieved by:

- The action of the fuse or circuit breaker being fast enough to open the circuit before the let-through energy can attain a value that would cause damage by overheating, arcing or mechanical stress; and
- The protective device being capable of opening the circuit, under these high fault current conditions, without damage to itself.

Short Circuit Current

In the case of a short circuit the only limit to the value of current in the circuit is the impedance of the faulty circuit, and the available short circuit energy. This includes the impedance of the supply source, usually a distribution transformer provided by the network operator.

Transformer Impedance

The impedance of a transformer is usually stated as the percentage of the primary-rated voltage that is necessary to cause full-load current in the secondary if the load terminals have a short across them.
A common transformer impedance value is 5%. If 5% of supply voltage will produce full load current, then, with a secondary short circuit and normal supply voltage of 100%, twenty times the rated full load current will be present.

$$\text{Short circuit current} = \text{Full load current x } \frac{100}{\text{Impedance \%}}$$

A distribution transformer having a full load current rating of 500 amps and an impedance of 5% would have a theoretical short circuit current of 20 x 500 or 10 000 amps. Since the heating effect of current is proportional to the square of the current, doubling the current results in four time the heating effect.
Currents of thousands of amps can result in explosions and catastrophic damage to the cables and related equipment.

Full Load Current

The rated full load output current of a typical three-phase distribution transformer is given by the equation:

$$IFL = \frac{kVA \times 1000}{\sqrt{3} \times VL}$$

So the rated full load current of a 500 kVA, 400/230 volt three phase distribution transformers with an impedance of 5% is:

$$IFL = \frac{500 \times 1000}{\sqrt{3} \times 400}$$

$$= 721.7 \text{ A}$$

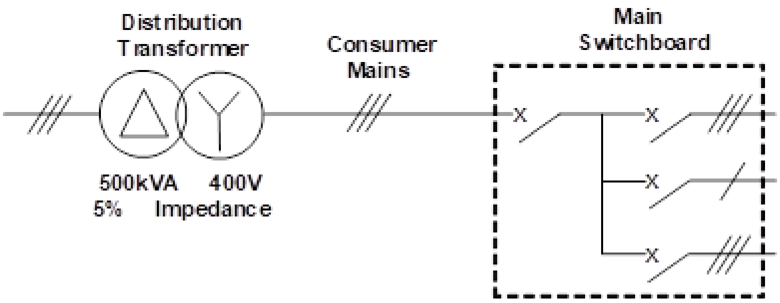
Prospective Fault Current

The available short circuit current (I_{SC}) if the 400 volt 500 kVA transformer had an impedance of 5% would be:

$$Isc = IFL \times \frac{100}{Z\%}$$

$$= 721.7 \times \frac{100}{5}$$

$$= 14.434 \text{ amps}$$



Impedance/Phase of Supply

If the available short circuit current of the 400 volt 500 kVA transformer was 14 434 amps, the supply impedance per phase (Z_1) would be:

$$Z1 = \frac{Uo}{ISC}$$

$$= \frac{230}{14.434}$$

$$= 0.0159 \text{ ohms}$$

The prospective fault current (fault level) per phase at the main switchboard is limited by the impedance of the supply plus the impedance of the cables from the source to the switchboard (the consumers' mains) (Z_2):

$$IFault = \frac{Uo}{Z1 + Z2}$$

The impedance of the consumer's mains can be found from relevant tables if the cable size, type and length are known.

As per AS/NZS 3000, B4.3 it states that reactance may generally be ignored for conductors of 35mm^2 or less where the active and earthing conductors are in close proximity to one another.

As the example below is less than 35mm^2 then we only need the resistance values (Rc) from AS/NZS 3008.1.1.

AS/NZS 3008.1.1
TABLE 35
a.c. RESISTANCE (Rc) AT 50 Hz
CABLE TYPE: MULTICORE WITH CIRCULAR CONDUCTORS

1	2	3	4	5	6	7	8	9	10
Conductor Size mm²	a.c. resistance (Rc) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	-	-	-	-
1.5	14.9	15.7	16.5	17.3	18.4	-	-	-	-
2.5	8.14	8.57	9.01	9.45	10.0	-	-	-	-
						-	-	-	-
4	5.06	5.33	5.61	5.88	6.24	-	-	-	-
6	3.38	3.56	3.75	3.93	4.17	-	-	-	-
10	2.01	2.12	2.23	2.33	2.48	-	-	-	-
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.710	0.956	1.01	1.06	1.11
50	0.426	0.449	0.471	0.494	0.524	0.706	0.745	0.784	0.822
70	0.295	0.311	0.327	0.343	0.364	0.488	0.515	0.542	0.569
90	0.214	0.225	0.236	0.248	0.262	0.353	0.373	0.392	0.411
120	0.170	0.179	0.188	0.197	0.209	0.280	0.295	0.310	0.325
150	0.139	0.146	0.153	0.160	0.170	0.228	0.241	0.253	0.265
185	0.112	0.118	0.123	0.129	0.136	0.182	0.192	0.202	0.212
240	0.0870	0.0912	0.0955	0.0998	0.105	0.140	0.148	0.155	0.162
300	0.0712	0.0745	0.0778	0.0812	0.0852	0.113	0.119	0.125	0.131
400	0.0580	0.0605	0.0630	0.0656	0.0685	0.0897	0.0943	0.0988	0.103
500	0.0486	0.0506	0.0525	0.0544	0.0565	0.0730	0.0765	0.0800	0.0835

* For the a.c. resistance of tinned copper conductor, multiply copper value by 1.01.

Fault level at Main Switchboard

If the consumers mains consisted of 30 metres of V90 TPS 16mm² copper cable the resistance of the active conductor would be approximately 1.40 ohms per phase (from Table above).

Note 1: Ω/km.

Note 2: The normal operating temperature of thermoplastic cables, including flexible cords installed as installation wiring, is based on a conductor temperature of 75° C. Where V90 is documented in the above statement, V75 conductor temperature is used as shown in the calculation below.

$$Z = \frac{L \text{ x } Rc \text{ x } 2}{1000}$$

$$Z = \frac{30 \text{ x } 1.40 \text{ x } 2}{1000}$$

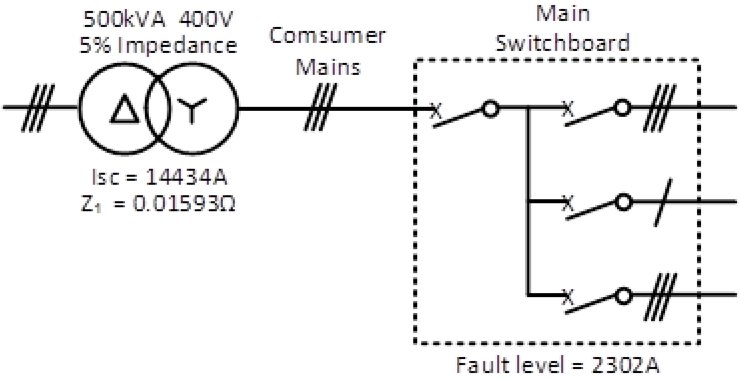
Z = 0.084 ohms

The prospective fault current level at the main switchboard would be:

$$I_{Fault} = \frac{Uo}{Z1 + Z2}$$

$$= \frac{230}{0.0159 + 0.084}$$

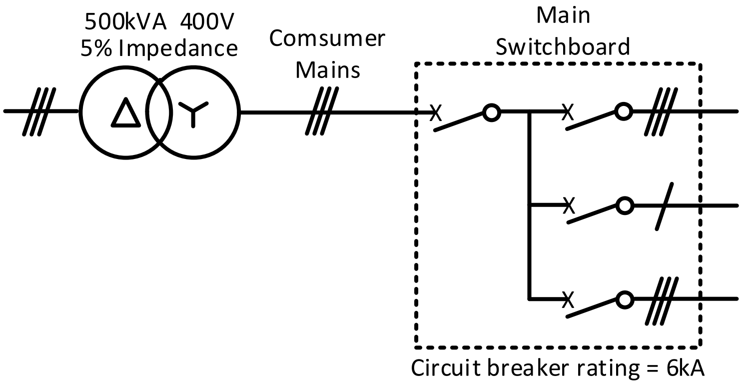
$$I_{Fault} = 2302 \text{ amps}$$



Circuit Breaker Rating

Since the prospective fault current at the main switchboard is 3831 amps, the circuit breakers on the main switchboard need to be rated at a short circuit current at or above this value. A rating of 6kA would be suitable.

Note: 6kA is the minimum kA rating for Domestic and Commercial installations in WA.



The kA rating of a circuit breaker will be written on it. Determination of this is done by the manufacturer, by means of a short circuit test. If they test it at a short circuit current of 6kA, and it successfully interrupts the fault current without any undue damage to its internal components, then they rate it at 6kA and stamp the device accordingly. Higher kA rating circuit breakers are constructed using heavier components.

Equation Summary

$$I_{FL} = \frac{kVA \times 1000}{\sqrt{3} \times V_R} \text{ (Transformer full load current)}$$

$$Isc = I_{FL} \frac{100}{Z\%} \text{ (Transformer short circuit current)}$$

$$Zphase = \frac{Uo}{Isc} \text{ (Supply impedance per phase [Z1])}$$

$$Ifault = \frac{Uo}{Z1 + Z2} \text{ (Prospective fault current at switchboard)}$$

Fault Loop Impedance

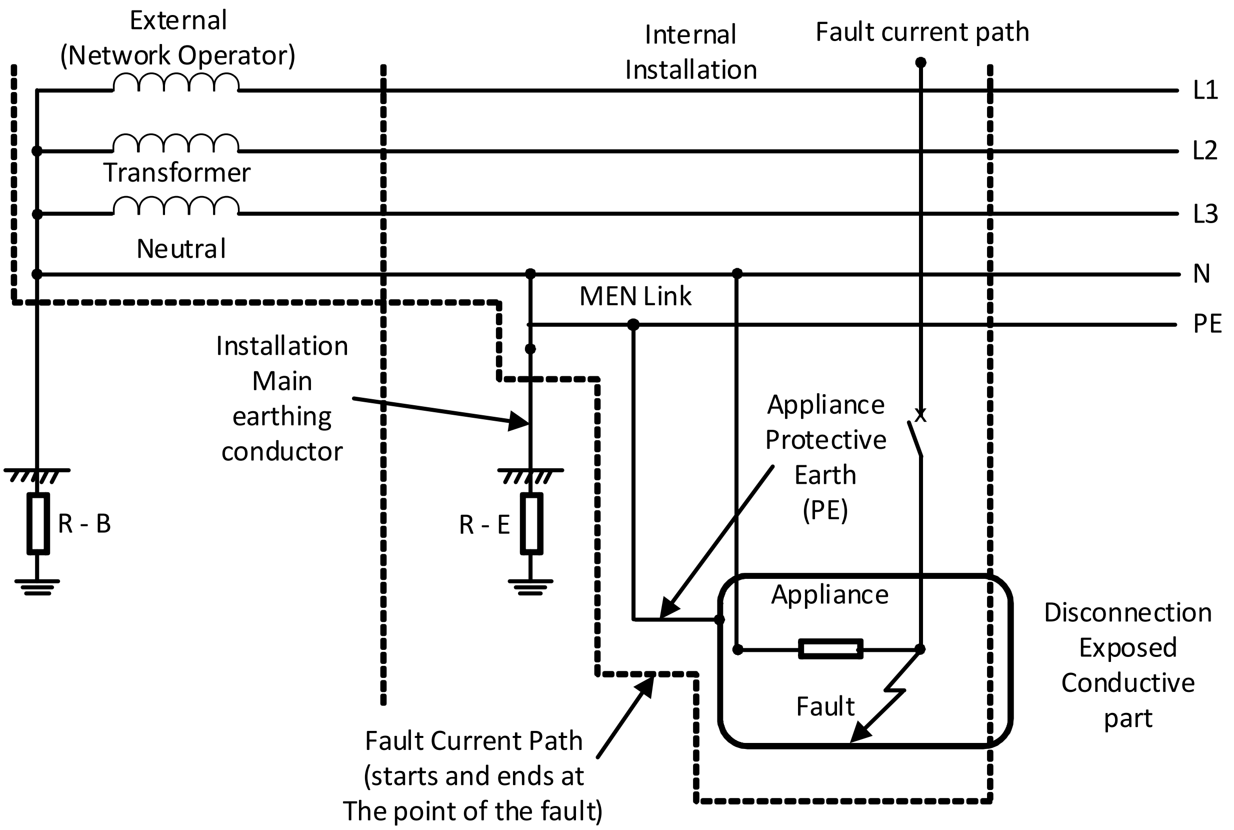
Fault-loop impedance is the impedance of the conductors in the series path taken by the current in the event of a fault between an active conductor and an earth fault, starting and ending at the point of the earth fault.

AS/NZS 3000 requires that each circuit be protected such that automatic disconnection of supply occurs within a specified disconnection time when a fault of negligible impedance occurs between an active conductor and a protective earthing conductor or an exposed conductive part anywhere in an electrical installation. See Clause 1.5.5.3(d).

This condition is satisfied when the fault-loop impedance is sufficiently low to allow enough current to flow in the fault-loop to cause the circuit protection device to operate within the specified time, thus limiting the touch voltage as required by Clause 1.5.5.3(c).

Fault Current Path (MEN)

The fault current path (or fault loop) in a MEN system starts and ends at the point of the fault. At the instant of the fault, current will flow through the fault loop and its magnitude is only limited by the total system impedance which is obtained from all of the individual impedances in the fault loop (see AS/NZS 3000 - Clause 5.7)



Times

The maximum disconnection time for 230/400V supply voltage shall not exceed the following (See AS/NZS 3000 Clause 1.5.5.3(d):

(i) 0.4 seconds for final sub-circuits that supply:

  a. socket-outlets having rated currents not exceeding 63A; or
  b. hand-held Class I equipment; or
  c. portable equipment intended for manual movement during use.

(ii) 5 seconds for other circuits including submains and final sub-circuits supplying fixed or stationary equipment.

Circuit Breaker Mean Tripping Current

The maximum value of fault loop impedance (Z_S) can be calculated for circuits protected by circuit breaker using manufacturers' information relating to the approximate mean tripping current for the circuit breaker.
The mean tripping current for typical circuit breakers can be taken as:

- Type B = 4 times rated current
- Type C = 7.5 times rated current (e.g. general purpose loads)
- Type D = 12.5 times rated current (e.g. high inductive loads)

See AS/NZS 3000 Clause B4.5 and Table B1 – note the 230V.

Fault Loop Impedance Equation

The fault loop impedance (Z_S) for a circuit breaker can be calculated using equation given in AS/NZS 3000 Appendix N°: B4.5:

$$Zs = \frac{Uo}{Ia}$$

Uo = nominal phase voltage
Ia = size of circuit breaker

If the length and cross sectional area (CSA) of supply conductors are unknown the calculated impedance value can be reduced to 80% (see AS/NZS 3000 Appendix No: B5.2.1(b).

$$\frac{0.8 \times Uo}{Ia}$$

Fault Loop Impedance Calculation

A 230 volt final sub-circuit supplies a load consisting of a 10A socket outlet protected by a 16A,
Type C, 8 kA circuit breaker. Determine the maximum internal fault loop impedance of the circuit if the supply is not available.

$$Zs = \frac{Uo}{Ia}$$

$$= \frac{230}{16 \times 7.5}$$

$$= 1.92 \text{ ohms}$$

Since there is no load on the installation, the impedance value can be reduced to 80% (see AS/NZS 3000 Appendix No: B5.2.1.b), so the maximum internal fault loop impedance for this circuit is 0.8 of 1.92 ohms which is 1.54 ohms.

Activity 24 Answers found in AS/NZS 3000 and AS/NZS 3008.1.

Note to Trainer and Assessor – Answers to some of the questions will come from the learners own experience 'on the job' and 'off the job'.

Activity 25

Excerpt from the WA Electrical Requirements, Section 9

https://www.commerce.wa.gov.au/publications/wa-electrical-requirements-waer

9 Special Requirements for Installations in WA

Under Regulation 49 of the Electricity (Licensing) Regulations 1991, the requirements set out below, which are additional to or at variance with the Wiring Rules and other Australian Standards, are mandatory and take precedence over those appearing in the Australian Standards.

9.1 Application of Wiring Rules Part 1

Electrical installation designers choosing to use a Wiring Rules Part 1 design and installation solution (rather than apply the deemed to comply requirements of Part 2) must comply with section 1.9.4 of the Wiring Rules and the following additional requirements.
Designers must not adopt a Part 1 solution for the following types of electrical installations, which must comply with Part 2 of the Wiring Rules and the applicable standard or standards referred to in Section 9.12:

- domestic installations,
- construction and demolition sites,
- medical treatment areas,
- relocatable installations and the site installations to supply them,
- marinas and pleasure craft, and
- shows and carnivals.

Design Work

Designers must be competent to carry out designs that depart from Part 2 of the Wiring Rules under the provisions of section 1.9.4.1.

For the purposes of this requirement, the following persons may be considered competent:

- Currently licensed electricians with at least 10 years' experience in the design and construction of consumer electrical installations (other than domestic installations) since qualifying, including not less than 5 years design experience in total.
- Electrical designers holding a TAFE Advanced Diploma in Electrical Engineering (or equivalent) and have at least 5 years' experience in the design of consumer electrical installations (other than domestic installations).
- Professionally qualified engineers

The designer must establish and retain for at least 10 years a folder that contains:

- the document referred to in Clause 1.9.4.2 of the Wiring Rules, which contains the installation owner's or operator's acknowledgment and acceptance that some parts of the installation do not conform to Part 2 of the Wiring Rules; and
- the specific information listed in Clause 1.9.4.3 'Documentation' of the Wiring Rules.

The designer is also required to provide one copy of the folder and contents to the responsible person for the installation, and a further copy to the person engaged to verify the compliance of the installation.

The designer shall make his/her folder available for examination by an Inspector (Electricity), if requested.

Additionally, the designer shall complete Section A of the 'Part 1 Design and Verification Certificate'. (appended to the document)

Verification of Compliance

Both the design and construction of the parts of the installation that do not comply with Part 2 of the Wiring Rules are required to be independently assessed to confirm compliance with the requirements listed in the Wiring Rules Clause 1.9.4.1 paragraphs (a), (b) and (c), as required by Clause 1.9.4.4.

This verification assessment work may only be carried out by persons who:

- are not involved in the design of the installation; and
- do not report to the designer (i.e. They may be part of the same organisation, subject to these constraints); and who are one of the following:
  - Currently licensed electricians with at least 10 years' experience in the design and construction of consumer electrical installations (other than domestic installations) since qualifying, including not less than 5 years design experience in total.
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  - Professionally qualified engineers with at least 5 years' experience in the design of consumer electrical installations (other than domestic installations).

On completion of the verification assessment, the verifier may, if satisfied, complete Section B of the 'Part 1 Design and Verification Certificate' appended to this document.

It is the designer's responsibility to ensure the verification work is carried out.

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A copy of the certificate shall be provided to the network operator on request.

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9.2.1 Design

Single and multi-phase consumers mains shall have a minimum current-carrying capacity of 32A per phase, except for:

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  - Single-phase: 63A,
  - Multi-phase: 32A per phase and
- multiple installations which incorporate a domestic installation, where the minimum current carrying capacity shall be:
  - Single-phase: 63A,
  - Multi-phase: 63A per phase.

The cable sizes used for consumers mains to domestic premises shall be no less than:

- single-phase: 10 square millimetres, copper conductors, or
- three-phase: 6 square millimetres, copper conductors.

When calculating voltage drop in an installation, the component of voltage drop across the consumers mains shall be assessed using the maximum demand of the installation or 80% of the minimum current carrying capacity specified above, whichever is the greater.
The maximum length permitted for consumer mains is 30 metres, where voltage drop may determine the necessary cable size.

Installation designers should bear in mind the steadily growing demand maxima imposed by domestic dwellings, especially with the increasing popularity of air conditioning and possible electric vehicle charging.

To allow for demand growth, and the possibility of all-electric homes, designers and contractors should consider installing 16 and 10 square millimetre copper conductors respectively for single-phase and three-phase consumers mains.

9.3 Current-carrying capacity of cables in roof spaces

For the purpose of calculating current-carrying capacity, wiring systems shall be installed in the roof space of buildings on the assumption that ceiling thermal insulation, if not currently present, will be installed in the future, and must comply with the Wiring Rules on such basis.

9.5 Protection of PV Array DC cables

Insulated and sheathed d.c. cables may be installed in the cavity of double-brick walls without enclosure in heavy duty conduit (reference Clause 4.3.6.3.2 of AS/NZS 5033) but shall otherwise comply with the requirements of that Standard.

Such cables installed within brick veneer shall be mechanically protected by heavy duty conduit.

9.6 Equipotential Bonding in Shower Recesses and Bathrooms

Equipotential bonding of the conducting metal reinforcing mesh within concrete floors and walls forming part of a shower recess or bathroom is not required.

9.9 Reporting of Unsafe Electrical Installations

Where an electrical worker identifies a defect in an electrical installation that renders that installation unsafe, Regulation 62 of the Electricity (Licensing) Regulations 1991 requires that person to advise the electrical contractor, who shall report the matter to the owner and the relevant network operator (or the Director).

Such defects include but are not limited to:

- unenclosed electrical joints in ceiling spaces; or
- degraded wiring insulation.

Where occurrences of unenclosed joints or degraded wiring insulation have already been rectified, no reporting is required under Regulation 62.

The fitting of an RCD, while recommended, is not acceptable (on its own) as an effective remedial action for such defects.

9.10 Applicable Standards

References are made throughout this document to relevant technical standards that apply to various aspects of electrical installations.

Electrical work must be carried out so as to comply (where applicable) with the latest version of those standards listed in Schedule 2 of the Electricity (Licensing) Regulations 1991.

The solar panels, inverters, batteries and other components comprising a solar PV installation intended for grid connection must be acceptable to the relevant network operator. They also must be approved by the Clean Energy Regulator if the installation owner wishes to qualify for Small Scale Renewable Energy Credits.

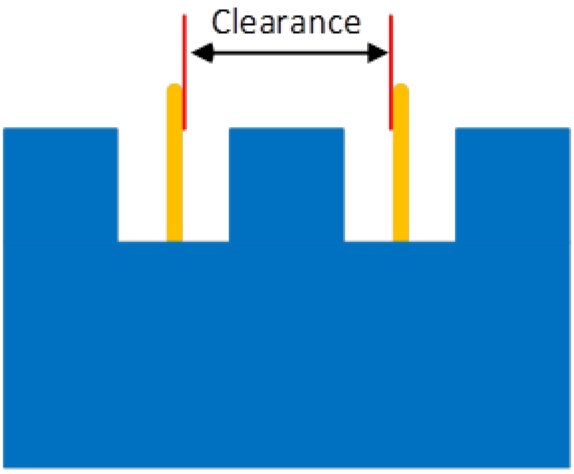
Activity 26 Answers found in AS/NZS 3000

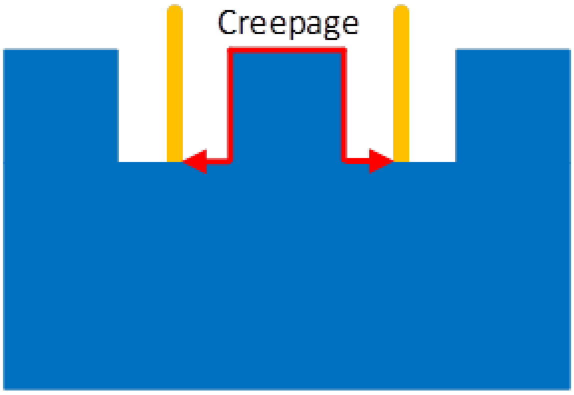
Activity 27 Answers found in AS/NZS 3000 and AS/NZS 3008.1.1

Activity 28 Answers found in AS/NZS 3000

Activity 29

What is the creepage and clearance distance?





Clearance: The distance between two electrical conductors through the air. In the simplest terms it is the distance a spark has to travel.

Creepage: The shortest distance between two conductors along the insulating surface. Creepage must be greater than or equal to clearance.

Activity 30 Answers found in AS/NZS 3000 and AS/NZS 3008.1.1

Note to Trainer and Assessor – Answers to some of the questions is a diagram will come from the learners own experience 'on the job' and 'off the job'.