Government of Western Australia
North Metropolitan TAFE

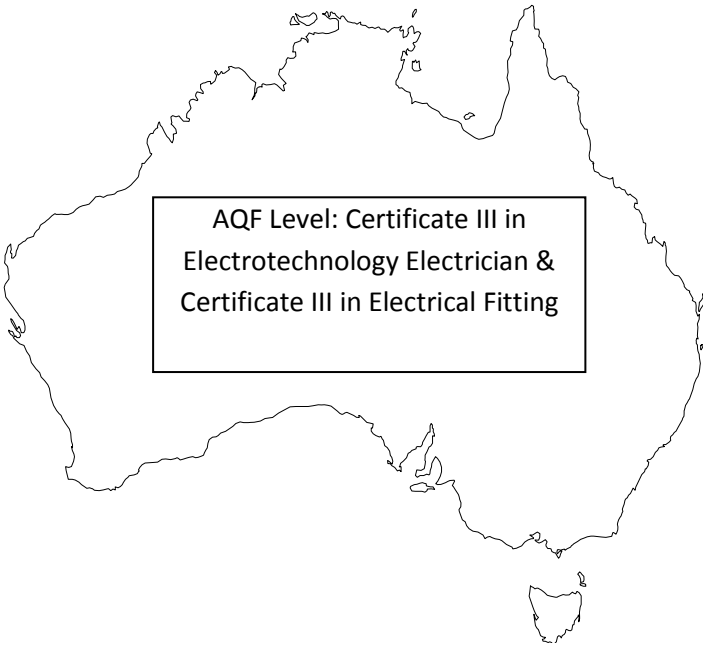
UEE11 Training Package Support Material
(Non-Endorsed Component)

Based on:
National Electrotechnology Industry Standards

Resource Book

UEENEEE107A

Use drawings, diagrams, schedules, standards, codes and specifications



North Metropolitan TAFE
V2 August 2018

Version 2 – 08/2018 – Alignment to AS/NZS3000:2018

Acknowledgements

This Unit Guide has been prepared by Balga Campus Lecturers.

It is intended for North Metropolitan TAFE students only.

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Certificate III in Electrotechnology Electrician UEE 30811

UEENEEE107A – Use drawings, diagrams, schedules, standards, codes and specifications

C O N T E N T S

Training Achievement Record:

Activity	Page	Topic	Completed	Lecturer's Signature

References

- Electrical Wiring Practice – Volume 1 (7th ed.) Pethebridge & Neeson
- Office of Energy Safety – W.A

Q-TRACKER REQUIREMENTS:

40 hours of practical training.

1. Performance requirements:

1a. Related to the following elements:

1. Prepare to use drawings, diagrams, manuals and schedules.
2. Use drawings, diagrams, schedules and manuals to obtain job information.
3. Use drawings, diagrams, schedules and manuals to convey ideas and information.
4. Prepare to use compliance standards, codes and specifications.

1b. For each element demonstrate performance:

− across a representative body of performance criteria,
− on at least 2 occasions,
− autonomously and to requirements,
− within the timeframes typically expected of the discipline, work function and industrial environment.

2. Representative range includes the following:

This unit shall be demonstrated in relation to assembly, installation, fault finding, maintenance or development work functions in any of the following disciplines:

- Appliances
- Business equipment
- Computers
- Data Communications
- Electrical
- Electrical Machines
- Electronics
- Fire protection
- Instrumentation
- Refrigeration and Air Conditioning
- Renewable / sustainable energy, and
- Security technology

3. Critical aspects of evidence.

Assessments shall be created and executed so as to contextualise for particular industry discipline being delivered and to demonstrate the following critical aspects.

A. Identifying and interpreting drawings, diagrams, schedules and manuals relevant to the work to be undertaken.

B. Using correct conventions and information in freehand drawings.

C. Obtaining compliance Standards and Codes applicable to particular disciplines.

D. Reviewing and understanding the format of compliance Standards and Codes that apply to particular disciplines.

E. Reviewing the format and content of typical job specifications.

F. Dealing with unplanned events.

UEENEEE107A – Use drawings, manuals, diagrams and schedules

Learning and Assessment Plan

Name of Lecturer: _____

Contact Details: _____

Delivery Mode/s: ☑ Face to Face ☑ On-Line ☐ Blended Delivery ☐ Other

Session	Nominal Duration	**Program of Work (Topics to be covered)**	Primary Reference
1	½ hour	Introduction / Overview	Resource Book
1	½ hour	Isolation Procedure	Resource Book
2		Architectural Drawings	Resource Book
3		Electrical Drawings	Resource Book
4		Circuit Diagrams	Resource Book
5		Wiring Diagrams	Resource Book
6		Building Construction Drawings	Resource Book
7		Intro to Regulations, Compliance Standards/Codes	Resource Book
8		Revision	Resource Book
8		Knowledge Assessment	Resource Book
9		Practical Assessment	Resource Book
9		Resits	Resource Book
Students' own time		Portfolio project assessment	Internet

I acknowledge that I have received and read this Learning and Assessment Plan

Student Name:_____ Signature: _____

Date: _____ ___

Lecturer Name	Lecturer Signature	Date

Assessment Strategy

Conditions of Assessment:

Normally learning and assessment will take place in an integrated classroom/ laboratory environment.

It is essential to work through the worksheets and activities in this workbook and follow the guidance of your lecturer. The worksheets and practical activities will provide the essential skills and knowledge outlined in this Unit and assist you in achieving competency.

Assessment Methods:

Written Knowledge Assessment – based on the Required Skills and Knowledge (RSAK). You must achieve a mark of 75% or more in this assessment.

Observed Skills Assessment – based on the Elements and Performance Criteria of this Competency Unit UEENEEEE107A. You must achieve a mark of 100% in this assessment.

On-Job-Training:

It is expected that the off-job component of this competency unit will be complemented by appropriate on-job development involving exposure to re-occurring workplace events and supervised experiences. (See Work Performance Tasks.) You are required to log your on-the-job training in your 'Q-Tracker' apprentice work book and on www.qtracker.com.au account.

Sufficiency of Evidence:

In all instances competency is to be attributed on evidence sufficient to show that a person has the necessary skills required for the scope of work. These include:

- Task skills - performing individual tasks
- Task management skills - managing a number of different tasks
- Contingency management skills - responding to irregularities and breakdowns in routines
- Job/role environment skills - dealing with the responsibilities and expectations of the work environment including working with others.

Evidence must demonstrate that an individual can perform competently across the specified range of activities and has the essential knowledge, understanding and associated skills underpinning the competency.

LABORATORY INSTRUCTIONS

Students working in laboratories at North Metropolitan TAFE Campus's do so on the condition that they agree to abide by the following instructions. Failure to observe the safety instructions will result in IMMEDIATE SUSPENSION.

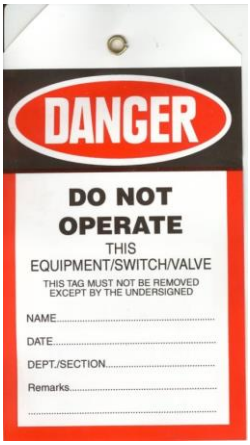
1. No circuit is to be plugged in or switched on without the specific permission of the lecturer in charge of the class. A circuit must be switched off, isolated and tested for ZERO VOLTS before any supply leads are removed. The DANGER TAG PROCEDURE must be used at all times.
2. Do not leave any circuit switched on any longer than necessary for testing. Do not leave any circuit switched on unattended.
3. Check each item of equipment before using. Report any broken, damaged or unserviceable equipment to your Lecturer.
4. All wiring must be disconnected at the end of each practical class or as each project is completed.
5. Make all connections in a safe manner with an appropriate connecting device. Unshielded 4mm banana plugs are not to be used for wiring.
6. Switch off, remove the plug from the socket and attach your DANGER TAG to the plug top before working on any project. It is not sufficient to simply turn the switch off.
7. When disconnecting your wiring from a connection made under a screw, undo the screw to remove the wiring, do not cut the wire off.
8. Observe the correct colour code for all wiring projects.
9. Test your circuit for short circuits with your multimeter before asking your Lecturer to switch circuit on. Test the Tester before and after EACH test.
10. Where an activity sheet is issued for a project, complete each step in the Procedure before moving to the next step. Advise your Lecturer when you have completed the activity.
11. Draw ALL DIAGRAMS in PENCIL so that they can be easily changed or corrected. Mark off each connection on your diagram as it is made.
12. Check the range before taking a reading with a multimeter.
13. Make sure that it is YOUR plug before inserting plug into an outlet.
14. Always switch multimeter OFF, or to the highest possible AC VOLTS range when you have finished using it.
15. Report any unexpected situations or events to your Lecturer.

Student's Signature _____ Date: _____

DANGER TAG PROCEDURE for ELECTRICAL TRADE LABORATORIES

THE FOLLOWING PROCEDURE IS COMPULSORY

1. The student is to attach a DANGER TAG on to the plug top of the project lead before proceeding with the allocated project. A danger tag must be attached to the plug top at all times, when the lead is NOT plugged into the supply outlet. Plug tops or leads are not to be connected to the supply outlet WHILE A DANGER TAG is attached.



2. The student is to assemble the project according to project instruction procedure and lecturer's directions in its isolated and de-energised state and report to the lecturer as necessary and on completion.

3. The lecturer is to:-
   a. Check the project for safety and
   b. Ensure that the student has performed a safety check, including a short circuit test using the recommended procedure.

4. When the lecturer is satisfied that the project is safe to connect and energise the lecturer is to instruct the student to REMOVE the DANGER TAG from the plug top.

5. The student is to plug in the project and switch it on in the presence of the lecturer.

6. The lecturer is to determine whether or not the project is operating satisfactorily.

7. If the project operates satisfactorily the student may take measurements using correct meters with regard to the safety risks associated with using the particular item of test equipment including;
   a. Selecting correct meter function,
   b. Holding meter probes correctly during measuring with fingers behind knurls (finger guards) at all times.

   This is to be done under general supervision of lecturer. The student is NOT to modify, disassemble or carry out ANY unsafe act.

8. If the circuit is to be modified the student must:
   a. Switch the circuit off,
   b. Disconnect the project from the supply,
   c. Attach the DANGER TAG to the plug top,
   d. Report to the lecturer for instructions,
   e. In the lecturer's presence the student is to:-
   f. TEST and VERIFY for ZERO VOLTAGE.
   g. Restart the DANGER TAG procedure from step 2 above.
9. When the student is satisfied that the project has been completed the student is to:-
   a. Switch the project off,
   b. Remove the plug,
   c. Replace the DANGER TAG on the plug top,
   d. Report to the lecturer for instructions,

   In the lecturer's presence the student is to:-
   e. TEST and VERIFY for ZERO VOLTAGE.

   The lecturer is then to instruct the student to:-
   f. Disassemble the project
   g. Remove the DANGER TAG and store the equipment in its designated place.

Failure to follow Danger Tag Procedures when working on practical activities and practical assessments will result in a '**Not yet competent'** comment recorded for this Unit of Competency – UEENEEE107A

Student's Signature _____ Date: _____

Prerequisite Unit(s)

2.1) Competencies

Granting competency in this unit shall be made only after competency in the following unit(s) has/have been confirmed.
UEENEEE101A Apply Occupational Health and Safety regulations, codes and practices in the workplace

2.2) Further Information:
For the full prerequisite chain details for this unit please refer to Table 2 in Volume 1, Part 2

PERFORMANCE CRITERIA

ELEMENT			
1	Prepare to use drawings, diagrams, schedules and manuals.	1.1	Established OHS risk control measures and procedures are followed.
		1.2	The need for drawings, diagrams, schedules or manuals is determined from the nature of the work to be undertaken.
		1.3	Established routines and procedures are followed to obtain drawings, diagrams, schedules or manuals required for the work to be undertaken.
2	Use drawings, diagrams, schedules and manuals to obtain job information.	2.1	Drawings, diagrams, schedules and/or manuals are selected, appropriate to the work being undertaken.
		2.2	Drawings, diagrams and schedules are interpreted using knowledge of drawing layouts, conventions and symbols.
		2.3	Dimensions are extracted from drawings and diagrams for application to work undertaken.
		2.4	Location of equipment is determined from equipment schedules and location diagrams.
		2.5	Manuals are reviewed to ascertain their format and where information relevant to the work to be undertaken is located.
		2.6	Information given in manuals is interpreted in relation to the work to be undertaken.

PERFORMANCE CRITERIA

ELEMENT		
3 Use drawings, diagrams, schedules and manuals to convey information and ideas.	3.1	Drawing conventions are used in neat freehand drawings to convey information and ideas to others involved in the work to be undertaken.
	3.2	Drawing conventions are used to neatly correct freehand original job drawing to show final 'as-installed' arrangement.
	3.3	Corrected drawings are forwarded to appropriate person(s) in accordance with established procedures.
4 Prepare to use compliance standards, codes and specifications.	4.1	Compliance Standards and Codes that apply to particular disciplines are sought and obtained.
	4.2	The format of compliance Standards and Codes that apply to particular disciplines are reviewed and understood.
	4.3	The purpose and format and typical content of job specifications are reviewed and understood.

REQUIRED SKILLS AND KNOWLEDGE

This describes the essential skills and knowledge and their level, required for this unit.

Evidence shall show that knowledge has been acquired of safe working practices and using drawings, diagrams, cable schedules, standards, codes and specifications.
The knowledge and skills shall be contextualised to current industry standards, technologies and practices.

KS01-EE107A Drawings, diagrams and schedules

Evidence shall show an understanding of drawings, diagrams and schedules used in electrotechnology work to an extent indicated by the following aspects:

T1 Architectural drawings encompassing:

- site plans, floor plans detailed drawings and standard drawings
- architectural floor plan to determine the power and lighting or communications / audio/ video layouts required in a domestic installation
- site plan to locate the service point, consumers mains, communication services, main switchboard, distribution boards and/or builders supplies
- standard drawing scales to determine the actual lengths represented by dimensions on an architectural drawing
- reading and interpretation of floor plans to determine the location of the electrical/ communication/audio accessories and appliances
- Australian standard symbols used on floor plans to show the location of the accessories and appliances as detailed in an electrical schedule

T2 Electrical drawings encompassing:

- types of electrical drawings: block, circuit, wiring and ladder diagrams
- purpose and application of block, circuit, wiring diagrams and ladder diagrams
- Australian standard symbols used to represent components on electrical diagrams
- conventions used in and the features of circuit diagrams
- converting a circuit diagram to a wiring diagram
- identification of cable type, origin and route from a cable schedule
- developing a cable schedule for a given installation

T3 Circuit diagrams encompassing:

- purpose of circuit diagrams in the electrotechnology industry
- conventions used in and the features of circuit diagrams
- sketching basic circuit diagrams
- common symbols used in circuit diagram (Australian Drawing Standard AS/NZS 1102)
- developing switching charts to identify the terminals of various types of switches
- connecting equipment using circuit diagrams

T4 Wiring diagrams encompassing:

- purpose of wiring diagrams in the electrotechnology industry
- conventions used in and the features of wiring diagrams
- sketching basic wiring diagrams
- common symbols used in wiring diagram (Australian Drawing Standard AS/NZS 1102)
- connecting equipment using wiring diagrams

T5 Building construction drawings and diagrams encompassing:

- building types: timber frames, brick veneer, double brick and metal frame
- identification of different types of: footings, floors, external walls, roofs, interior walls

REQUIRED SKILLS AND KNOWLEDGE

- typical cable routes through buildings, structures and premises
- sequence of each constructional stage for brick, brick veneer and timber cottages
- identification of the stages at which the electrical/communications - first and second fixing occurs in the constructional sequence
- areas of cooperation between electrical/communications and other building trades

KS02-EE107A Introduction to regulations, compliance standards and codes

Evidence shall show an understanding of regulations, compliance standards and codes that apply to electrical work to an extent indicated by the following aspects:

T1 Regulation for undertaking electrical work encompassing:

- scope of work covered by licensing in the electrotechnology industry (Electrical licensing)
- legislative requirements for ensuring electrical or electronic equipment is safe i.e. compliance requirements of electrical installations

T2 Standards philosophy and format encompassing:

- performance verses prescriptive requirements
- purpose of technical standards and their development
- role of standards Australia/New Zealand, International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC)
- how standards are used in compulsory and accreditation compliance schemes.
- arrangement and use of technical standards in relation to electrical and electronic work
- how to read and apply a standard
- Standards and codes that apply to all types of electrical installations
- Standards include Standards mandated under regulation (e.g. Wiring Rules) or by an authority, deemed-to-comply standard and local service requirements (e.g. Service rules).
- Codes include those applicable to electrical safe working practices and some aspects of the Building Code of Australia.

T3 Purpose, format and content of typical job specifications encompassing:

NATSPEC specification system - provide the most common templates on which job specification are written.

Subject Matter in Electrical Wiring Practice and Electrical Principles Trades Volume 2			
RKAS	**TOPIC / CONTENT**	**Electrical Wiring Practice Volume 1**	**Electrical Principles Trades Volume 2**
KS01-EE107A	Drawings, diagrams and schedules	Chapter 6: drawings, diagrams, schedules and documents used in electrical work	Chapter 12 Electrical drawing practices
T1	Drawings, diagram types, layouts and conventions	6.1 Series and parallel circuits in wiring. 6.2 Electrical circuits and wiring diagrams	12.1 circuit diagrams 12.2.Conventions in line work 12.4 placement of circuit components
T2	Standard electrical symbols used in electrical schematic, ladder and wiring diagrams	6.2 Electrical circuits and wiring diagrams	12.3 Symbols used in electrical circuit diagrams
T3	Building construction drawings and diagrams	6.3 Circuits in general wiring 6.4 Undertaking electrical work	12.6 Other circuit representations – architectural electrical diagrams
KS02_EE107A	Introduction regulations, technical standards, codes and specifications	Chapter 3 Regulations and standards Chapter 6 Drawings, diagrams, schedules and documents used in electrical work	
T1	Regulation for undertaking electrical work	3.1 Electrical licensing	
T2	Standards philosophy and format	3.2 standards 3.3 Format of the wiring rules AS/NZS 3000:2007 3.4 Using AS/NZS 3000:2007 3.5 Wiring Rules – clause 1.4 definitions 3.6 Fundamental principles (wiring rules part 1)	
T3	Purpose, format and content of typical job specifications	6.5 Working with specifications, schedules and drawings	

Architectural Drawings Introduction

The training of electricians includes practical work involving the control of light and power circuits, and to perform this work efficiently they must work with, and be able to interpret, electrical diagrams. The electrician must also have a plan for the precise location of equipment, outlets and control positions; this implies a working knowledge of building construction methods and sequence. In addition, the conduit/cable runs and layout require planning and, unless a job is small, a diagram of switchboard layout and wiring is usually necessary.

The actual wiring circuits and connections require reference to wiring diagrams, unless they are standard simple types, in which case the diagram is carried as a mental picture. However, remembering even the simplest wiring circuit or layout initially requires the study of relevant diagrams and circuits.

In the case of a simple installation such as an additional light point or socket-outlet, both the wiring layout and the necessary job materials would also probably be retained in the memory of the electrician on the job. However, even in this simple example, although there is no written record the requirements still exist.

The conclusion is that, for all jobs, no matter how simple or how complex, it is essential for plans, specifications, material lists and schedules to be prepared. The number and extent of these will depend on the extent and complexity of each job. This chapter is concerned with the development and interpretation of electrical drawings and specifications, and how they are used in preparing materials lists.

ARCHITECTURAL ELECTRICAL DIAGRAMS

Architectural drawing and building construction is a broad subject that cannot be covered in detail here. The following material will examine how electrical architectural designers indicate the actual layout to those installing the appliances, switches and outlets in the building they have designed.

An architectural electrical drawing indicates to the installing electrician where the outlets are to be placed. It does not give any detail on how wiring and circuit connections are to be carried out.

In most cases the architectural electrical drawing is accompanied by a set of specifications and a schedule. These may give much more detail on the work to be done.

An electrical architectural drawing is a drawing of the ‘floor plan’ of a building to which the electrical symbols have been added. A floor plan of a building is a view looking down on the building, imagining that the building had been cut through at a level of 1250 mm from the floor and the upper part removed. This can be seen in Figure 12.15 and the actual floor plan can be seen in Figure 12.16.

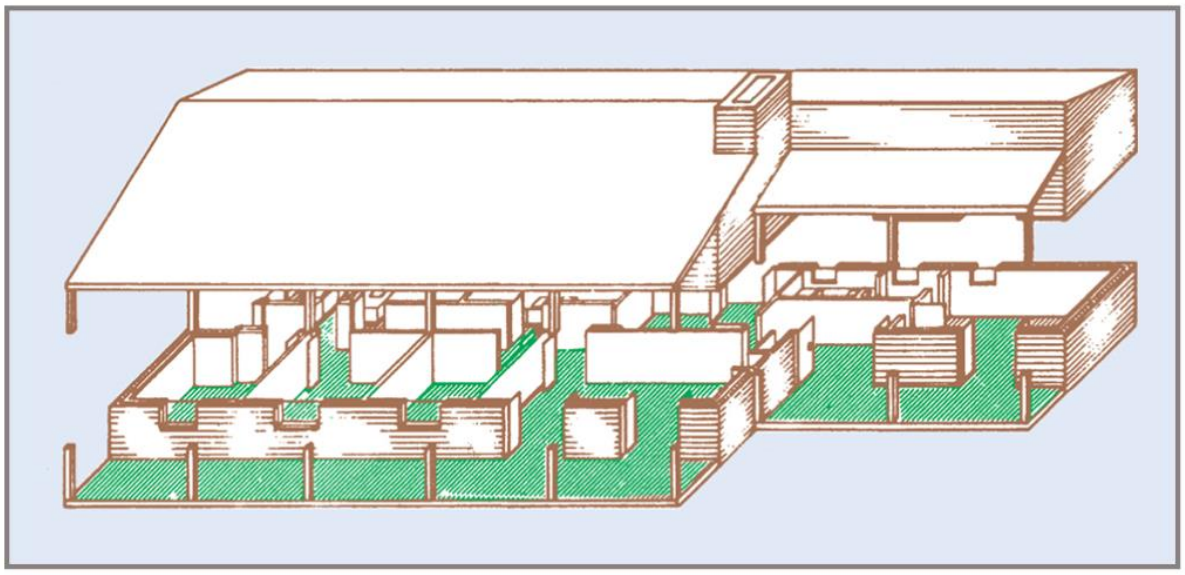


Figure 12.15

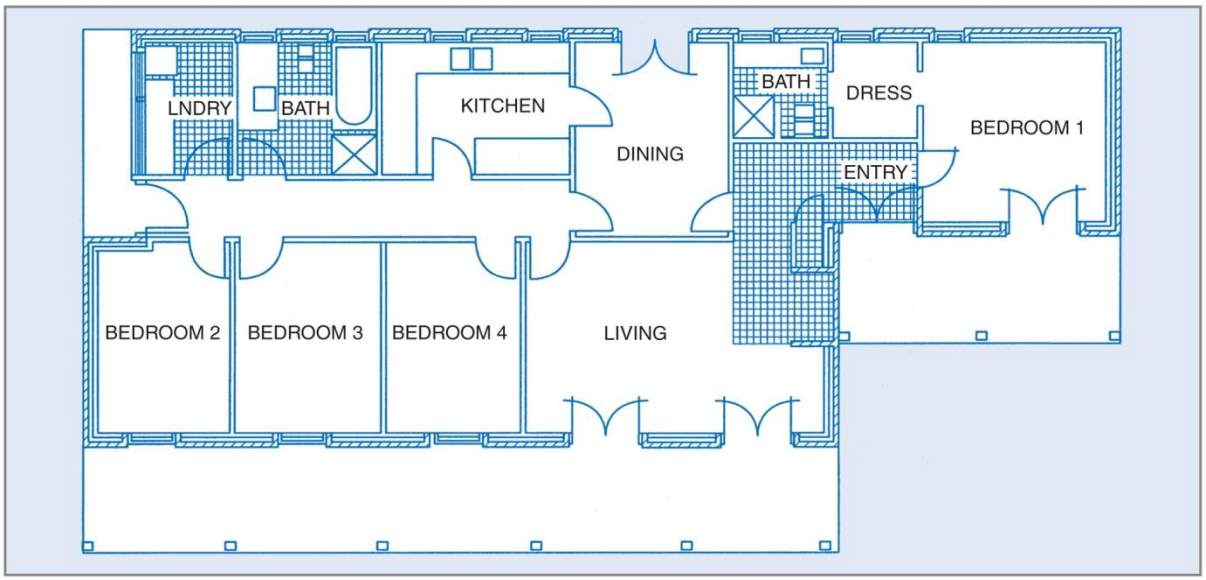
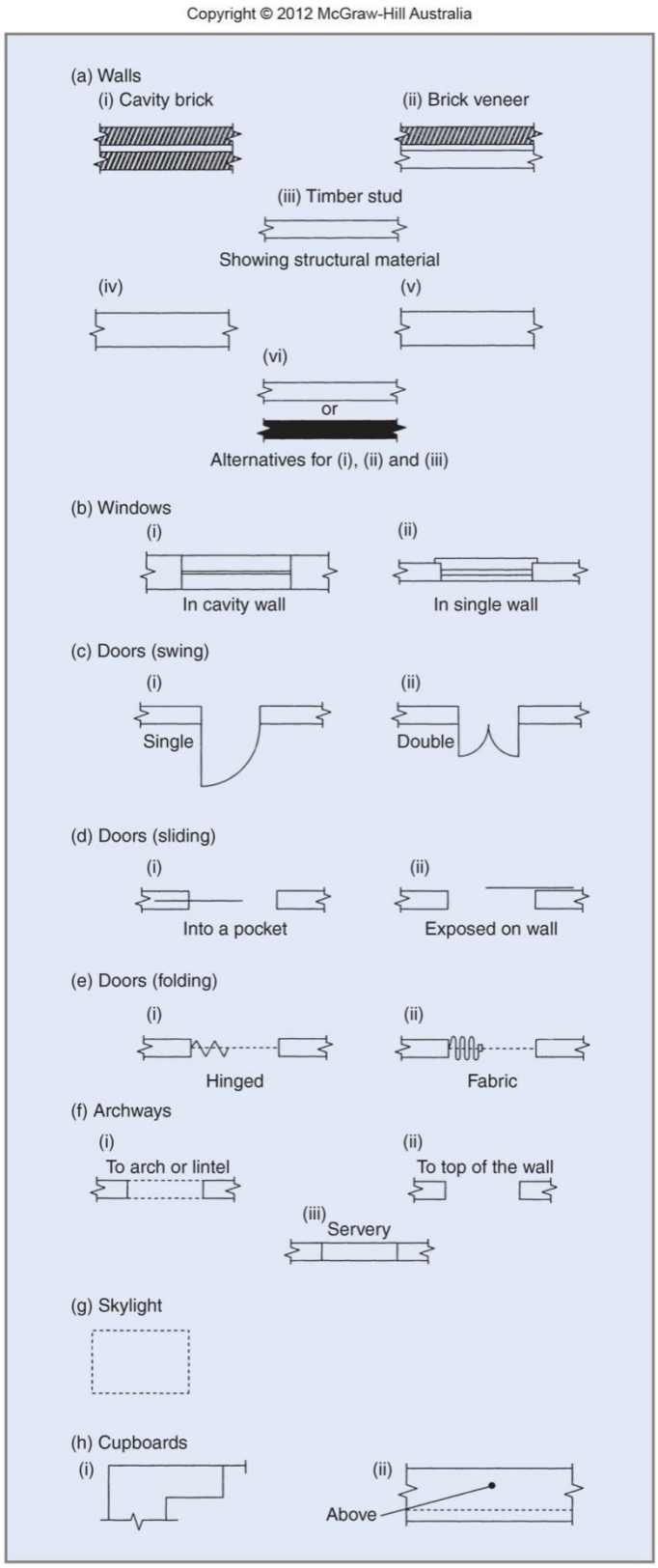


Figure 12.16

Note that the drawing of Figure 12.16 uses certain features that might not be familiar. Check these features with the representations shown in Figure 12.17, which shows the most common representations found in domestic floor plans.

Figure 12.17



The features of importance to the installing electrician are doors.

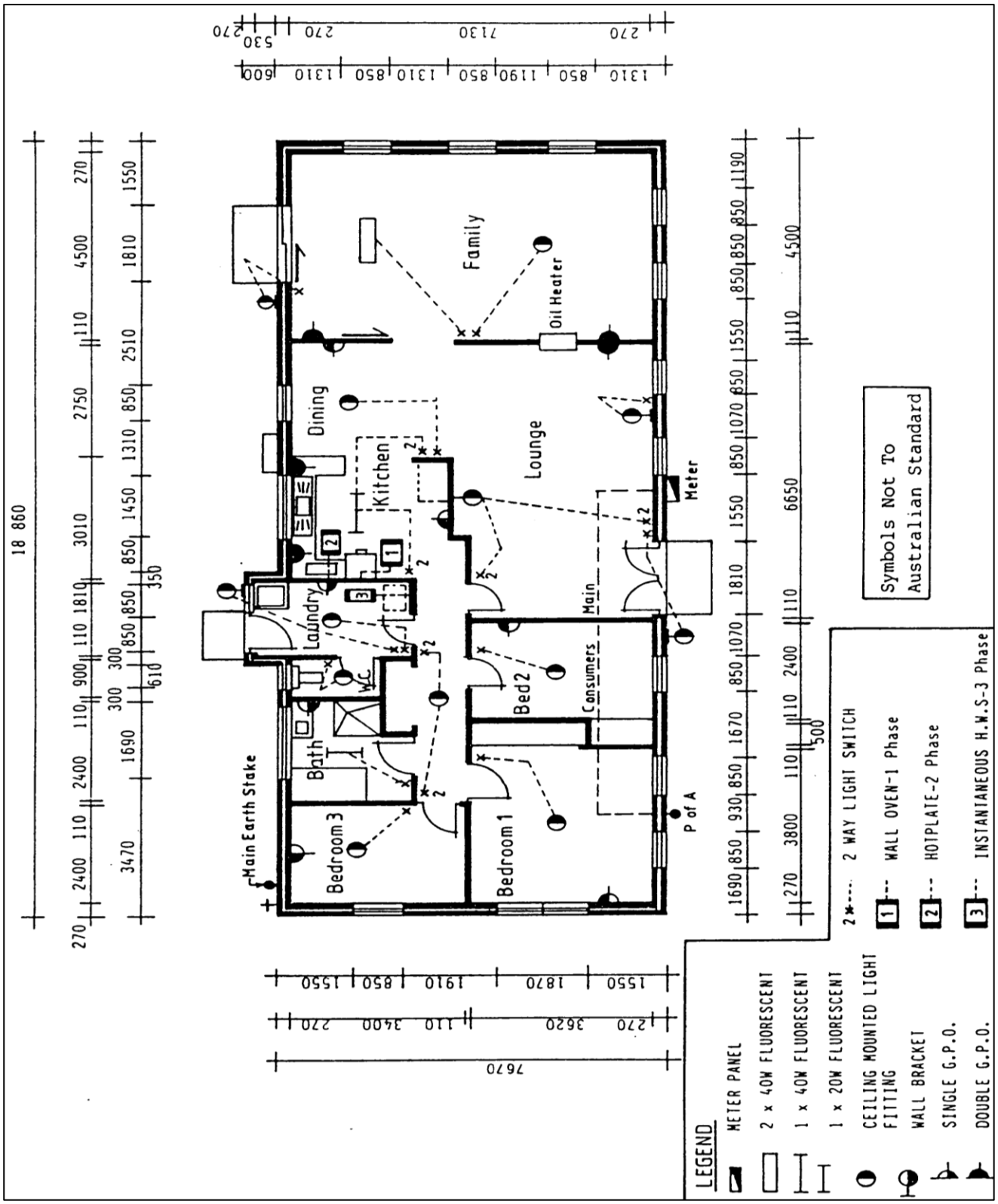
The hinge side of the door is important because it is more practical to install light switches on the latch side of the door frame, rather than behind the door.

Electrical symbols are drawn on the floor plan to make the architectural electrical drawing.

The symbols used on these diagrams are different to those used in either schematic circuit diagrams or wiring diagrams.

They have been derived so that they are easy to draw, easy to recognise and distinctive.

Sample Floor Plan - Domestic Residence



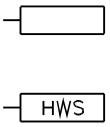
ELECTRICAL ARCHITECTURAL LOCATION SYMBOLS

	DESCRIPTION	SYMBOL
1	SWITCHBOARD (Main Switchboard)	MSB
2	UNDERGROUND LINE	
3	OVERHEAD LINE	
4	MAINS ENTRY BOX	
5	LUMINAIRE General symbol	
6	LUMINAIRE Fixed to wall	
7	LUMINAIRE Group of lamps eg. three 40W	3 x 40 W
8	LUMINAIRE With built–in switch	
9	SPOTLIGHT	
10	FLOODLIGHT	

	DESCRIPTION	SYMBOL
11	EMERGENCY LIGHTING LUMINAIRE	
12	FLUORESCENT LAMP (single)	
	(double)	
13	ONE–WAY SWITCH Single Pole	
	Two Pole	
	Three Pole	
14	SINGLE POLE PULL SWITCH	
15	DIMMER SWITCH	
16	TWO–WAY SWITCH	
17	INTERMEDIATE SWITCH	
18	TIME SWITCH	
19	PERIOD LIMITING SWITCH	t

ELECTRICAL ARCHITECTURAL LOCATION SYMBOLS

	DESCRIPTION	SYMBOL
20	GPO Single Phase	
21	GPO – double	
22	THREE PHASE SOCKET OUTLET	
23	TELEPHONE OUTLET	
24	CLOCK B Battery D Digital S Synchronous	
25	MOTOR General Symbol	
26	DC POWER SUPPLY Rectifier Unit	
27	ELECTRIC BELL	
28	ELECTRIC BUZZER	
29	HORN	

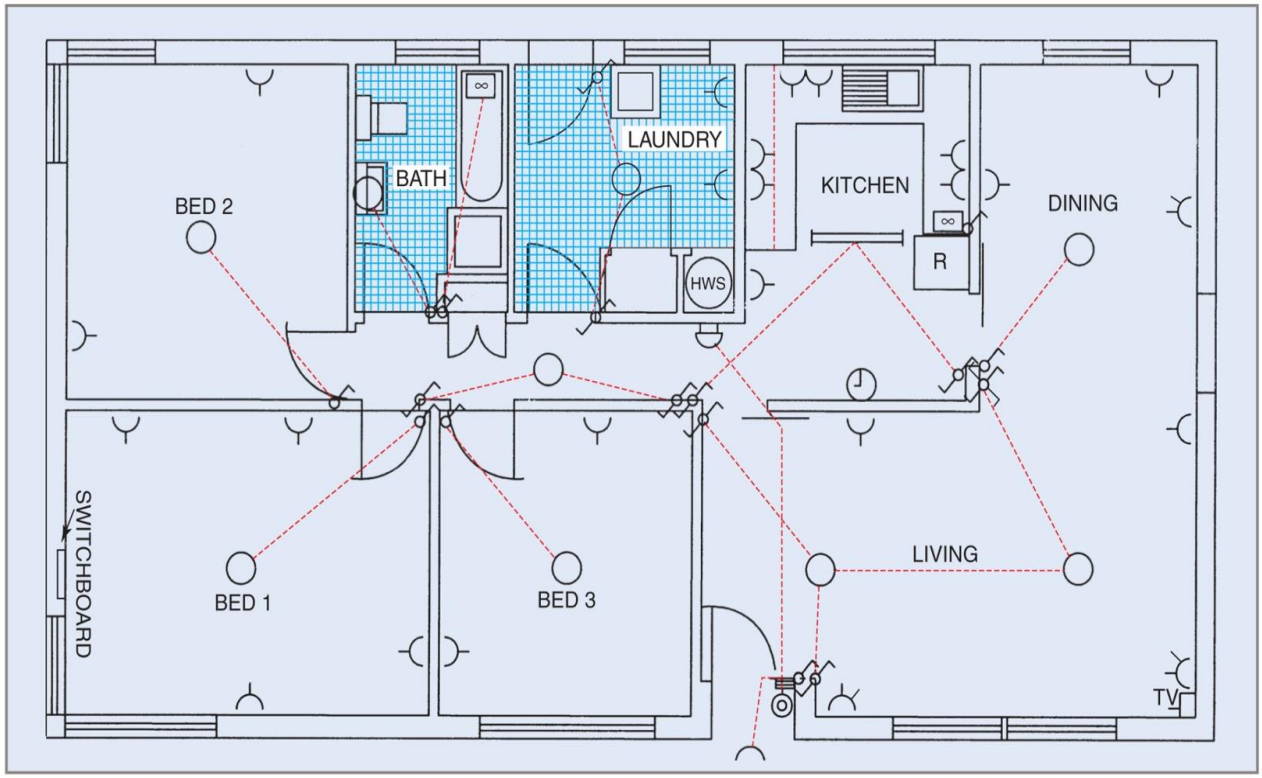
	DESCRIPTION	SYMBOL
30	PUSH BUTTON SWITCH	
31	ELECTRICAL APPLIANCE General Symbol HWS – Hot Water System AC – Air Conditioner EF – Exhaust Fan	

The main features of the drawing in Figure 12.19 are the symbols representing the outlets (luminaire, general- purpose outlets and appliances) and the switches. Another feature is that there are dashed lines between all switches and luminaire outlets. (‘Luminaire’ is the correct technical term for ‘lighting fitting’.)

The dashed lines simply represent which switches control particular luminaires. They do not represent the path of the wiring; this is left to the installing electrician.

Figure 12.19

Typical Floor Plan



Note that some lights are controlled by more than one switch. These special switches, two-way or intermediate, are indicated on the plan.

Also note that the bell push at the front door has a dashed line to the symbol representing the bell in the hall.

This tells the electrician where to position the doorbell and that it is controlled from a bell push near the front door.

Note the position of the general-purpose outlets, the major appliances and the main switchboard.

The drawing gives no details about how these outlets are to be wired and connected.

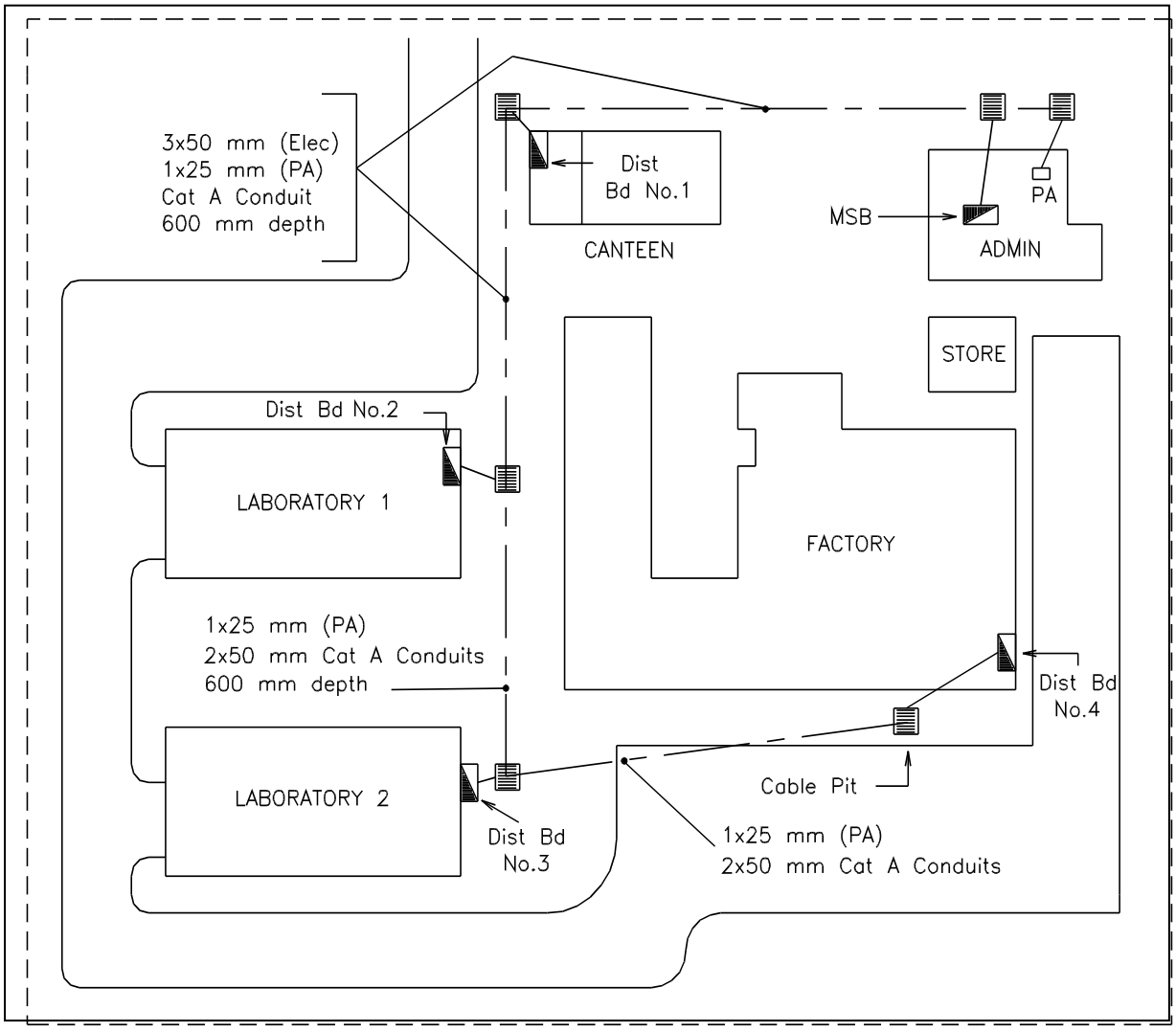
This is also left to the skill of the installing electrician, who will follow any instructions given in the specifications and will work within the requirements of the Standard AS/NZS 3000-2018.

Site Plans

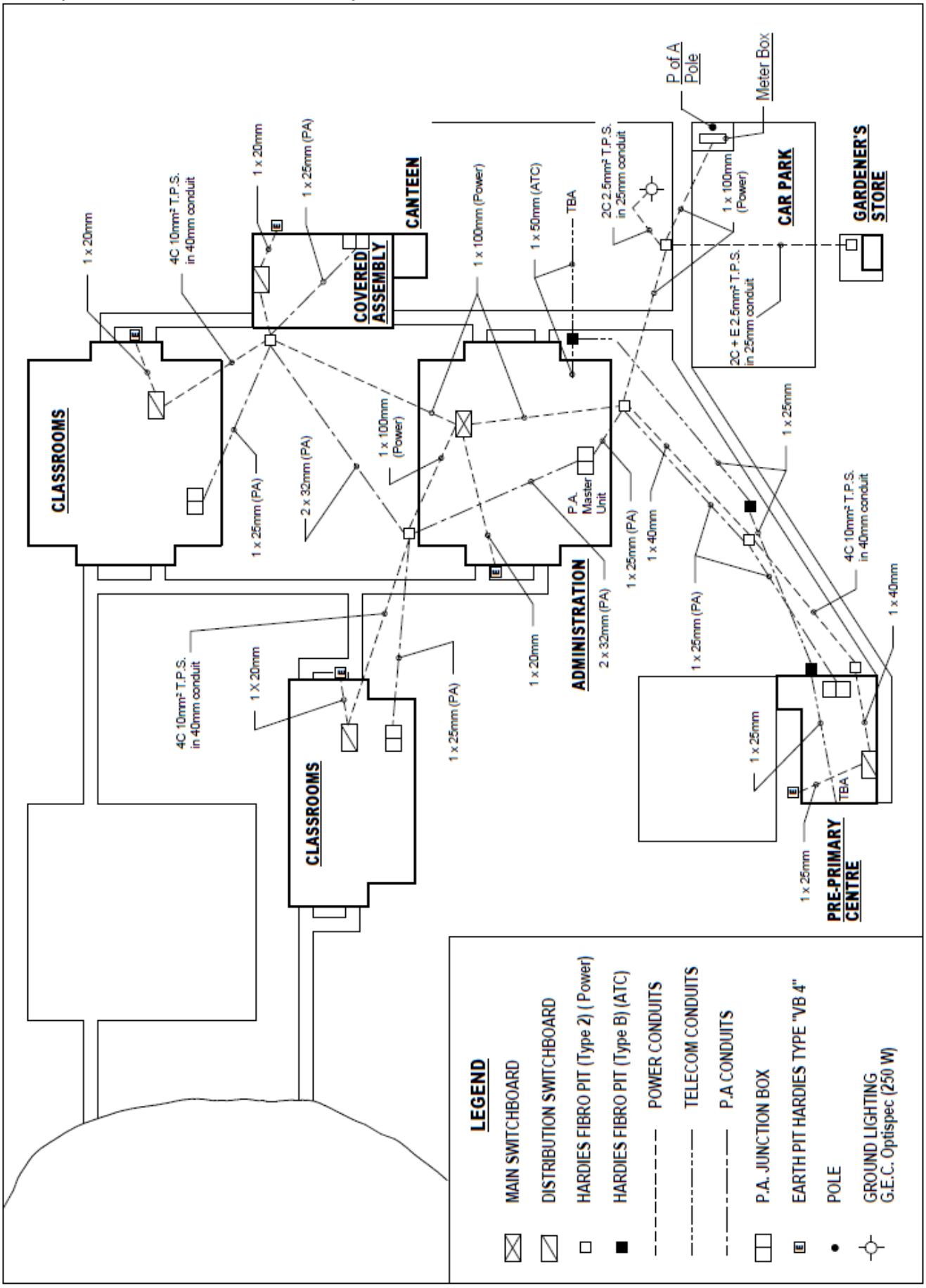
Site plans indicate the location of buildings, cable types, origin of circuits, switchboards, cable routes and lengths, cable pits, car parks, and lighting. They are general location diagrams which indicate the location of the site itself, as well as the buildings on it. If a site has its own sub-station it is shown on the site plan. Temporary electrical supplies available during construction of the buildings are also shown. Cable schedules can be developed from site plans if the relevant cable details are provided.

Typical Site Plan

Scale – 1:500



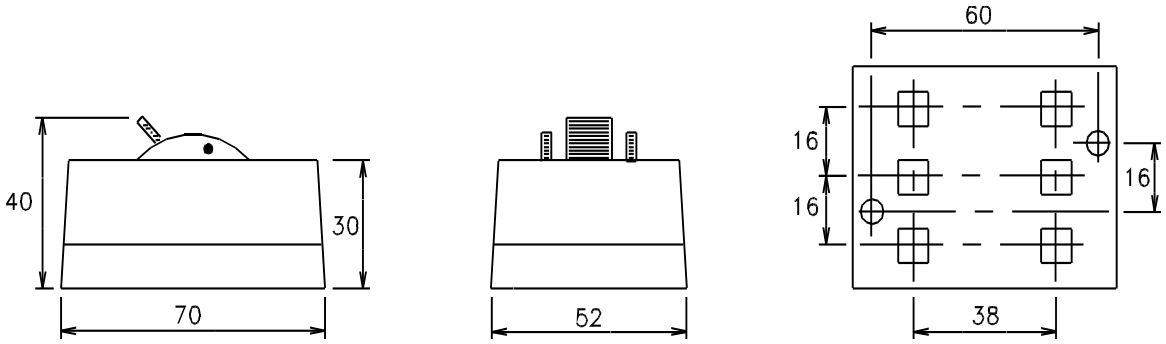
Sample Site Plan - Primary School



Standard Drawings

Standard drawings are drawings of items commonly specified, and which may change only slightly, if at all, over a long period.
These should be checked with each contract to ensure that no variation has taken place.

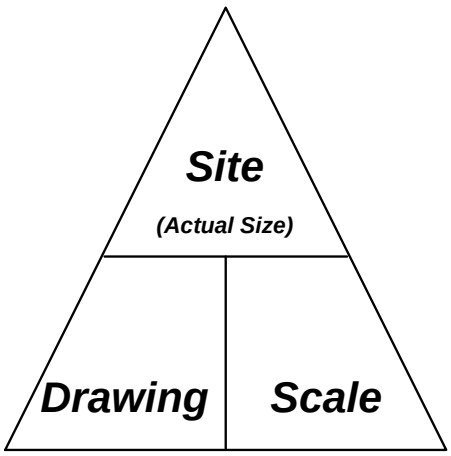
Typical Standard Drawing



Scales:

All good drawings should include a scale for the purpose of calculating distances to enable quantities to be correctly estimated.

A simple way to remember the formula for calculating actual sizes from drawings can be represented in the same way as Ohm's Law is represented in a triangle.



These are the equations to calculate site size, drawing size & the scale of the drawing.

$\text{Site} = \text{Drawing x Scale}$ $\qquad \text{Drawing} = \frac{Site}{Scale}$ $\qquad \text{Scale} = \frac{Site}{Drawing}$

The scale ratio is written as follows: **Multiplier:1** **e.g. 100:1**

On site measurements:

As a tradesperson you may be required to measure a building to enable you to estimate quantities of cable, conduit, tray etc. You will need to be able to sketch a basic floor plan, measure and scale for accuracy when estimating material quantities.

1. Devices used for measuring dimensions of buildings.

    1. Steel tape measure

Features, advantages and disadvantages

- Generally between 3m and 10m in length.
- Self-retracting and lockable at any point along the scale.
- Belt clip.
- Can be operated by one person.
- Metal tape is conductive and can potentially become live.
- Injuries can occur when tape self-retracts.
- Limited measurement distance means several measurements may be required to cover longer distances.
- Height measurements may require the use of a ladder or scaffold.

    2. Fibre tape measure

Features, advantages and disadvantages

- Up to 60m in length.
- Can measure around curves.
- Non-conductive tape.
- Not self-retracting tape.
- Requires anchoring or second operator to secure at start as tape is flexible.

3. Measuring wheel.

Features, advantages and disadvantages.

- Less limited measuring distance. Dependent on counter usually up to 999.99m and then counter will restart at zero.
- Less accurate than tape measure.
- Cannot access corners.
- Cannot measure vertical drops.

4. Digital measuring device.

Features, advantages and disadvantages.

- Typically up to 50m range.
- Highly accurate typically +/- 1.5mm over 50m distance.
- Can measure vertical distances without the use of a ladder or scaffold.
- Measurement storage and calculation functions.
- Measurements taken from one point. This feature is particularly useful when working in a roof space as there is no need to fully enter the area and risk falls or damage etc.
- Backlit display for use in low light conditions.
- Cannot measure around curves.
- Risk of eye damage if laser is used incorrectly.
- Laser viewing glasses (as shown) recommended for improvement of beam visibility.

Laser facts and safety considerations:

How is the hazard of a laser rated?

Lasers are classified according to the hazard associated with their emissions, as defined in the Australian/New Zealand Standard AS/NZS IEC 60825.1:2011 Safety of Laser Products Part 1: Equipment classification and requirements, AS/NZS IEC 60825.14:2011 Safety of Laser Products Part 14: A User's guide. AS2397:2015 is the Australian Standard that covers Safe use of lasers in the building and construction industry.

- Class 1 and 1M lasers are safe under reasonably foreseeable conditions of operation. Class 1M can be hazardous if the beam is viewed with magnifying optical instruments (hence the letter 'M' is added).
- Class 2 and 2M lasers emit visible light at higher levels than Class 1, but eye protection is provided by aversion responses such as the human blink reflex. Class 2M lasers can be hazardous if the beam is viewed directly with magnifying optical instruments.
- Class 3R lasers produce visible and invisible light that are hazardous under direct viewing conditions. There is low risk for eye injury provided the exposure time is short. There is no risk for skin injury.
- Class 3B lasers produce visible or invisible light that is hazardous under direct viewing conditions; either they are powerful enough to cause eye damage in a time shorter than the human blink reflex (0.25 seconds) or the blink reflex is by-passed due to the invisibility of the beam. Laser products with power output near the upper range of Class 3B may also cause skin burns.
- Class 4 lasers are high power devices capable of causing both eye and skin burns, their diffuse reflections may also be hazardous and the beam may constitute a fire hazard.

How are people exposed to Lasers?

In most circumstances, the general public should seldom encounter anything but the lowest classification lasers.

What are the effects of exposure to Lasers?

The eyes and skin are the organs primarily at risk from exposure to laser light. Health effects from exposure to laser light are generally divided into two categories: radiation and non-radiation hazards. Radiation hazards include injury to the eyes and skin from direct exposure to the laser beam or any reflections. Momentary viewing of the beam from a Class 2 laser may cause temporary flash-blindness, similar in effect to viewing a photographic flash at close range. However, unlike the photographic flash, a Class 2 laser can cause flash-blindness up to 50 metres or more. Many non-radiation hazards arise from the use of lasers including electrical hazards, chemical hazards, burns from heated surfaces, production of fumes, vapours and airborne contaminants from materials within the beam.

How can I reduce my risk from exposure to Lasers?

Most lasers encountered by the general public will either be inherently safe or fully enclosed within a device and so will not present a hazard under normal circumstances. In 1993, the Radiation Health Committee of Australia's National Health and Medical Research Council determined that consumer laser products should not exceed Class 2.

- May be hazardous if viewed through any type of optical magnifying device.
  i.e.: do not view a laser through spectacles, magnifying glass or direct through lens of SLR camera.
- May be hazardous if subject looks directly into laser and does not allow blink reflex to function.
  i.e.: do not look directly into the laser source and prevent your blink reflex from functioning.
- May cause flash blindness in cases where light has been directly shone into eyes for a short period.
  i.e.: at no time should you ever look directly into the laser source.
- In most instances class 2 is not considered hazardous under normal operating conditions.

Architectural Symbols and Drawings
WorkSheet 1-1

The following questions relate to the attached sheet of architectural location symbols, which are on **page 30**.

1. What is the number beside the symbol for a luminaire?
2. What is the number beside the symbol for a pull switch?
3. What is the number beside the symbol for a motor?
4. What is the number beside the symbol for a spotlight?
5. What is the number beside the symbol for a single fluorescent?
6. What is the number beside the symbol for a mains entry box?
7. What is the number beside the symbol for a telephone outlet?
8. What is the number beside the symbol for a three phase outlet?
9. What is the number beside the symbol for a wall light?
10. What is the number beside the symbol for a dimmer switch?
11. What is the number beside the symbol for a socket outlet (GPO)?
12. What is the number beside the symbol for an intermediate switch?
13. What is the number beside the symbol for a floodlight?
14. What is the number beside the symbol for an air conditioner?
15. What is the number beside the symbol for a main switchboard?
16. What is the number beside the symbol for a hotwater system?
17. What is the number beside the symbol for a triple pole switch?
18. What is the number beside the symbol for a two way switch?
19. What is the number beside the symbol for a double socket outlet?
20. What is the number beside the symbol for a push button?
21. What is the number beside the symbol for an exhaust fan?
22. What is a site plan and what information should it provide?
23. What is a floor plan and what information should it provide?
24. What are the main functions of architectural electrical drawings?

Go to page 32 to complete this worksheet.

SYMBOL SHEET

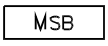
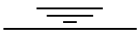
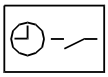
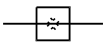
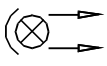
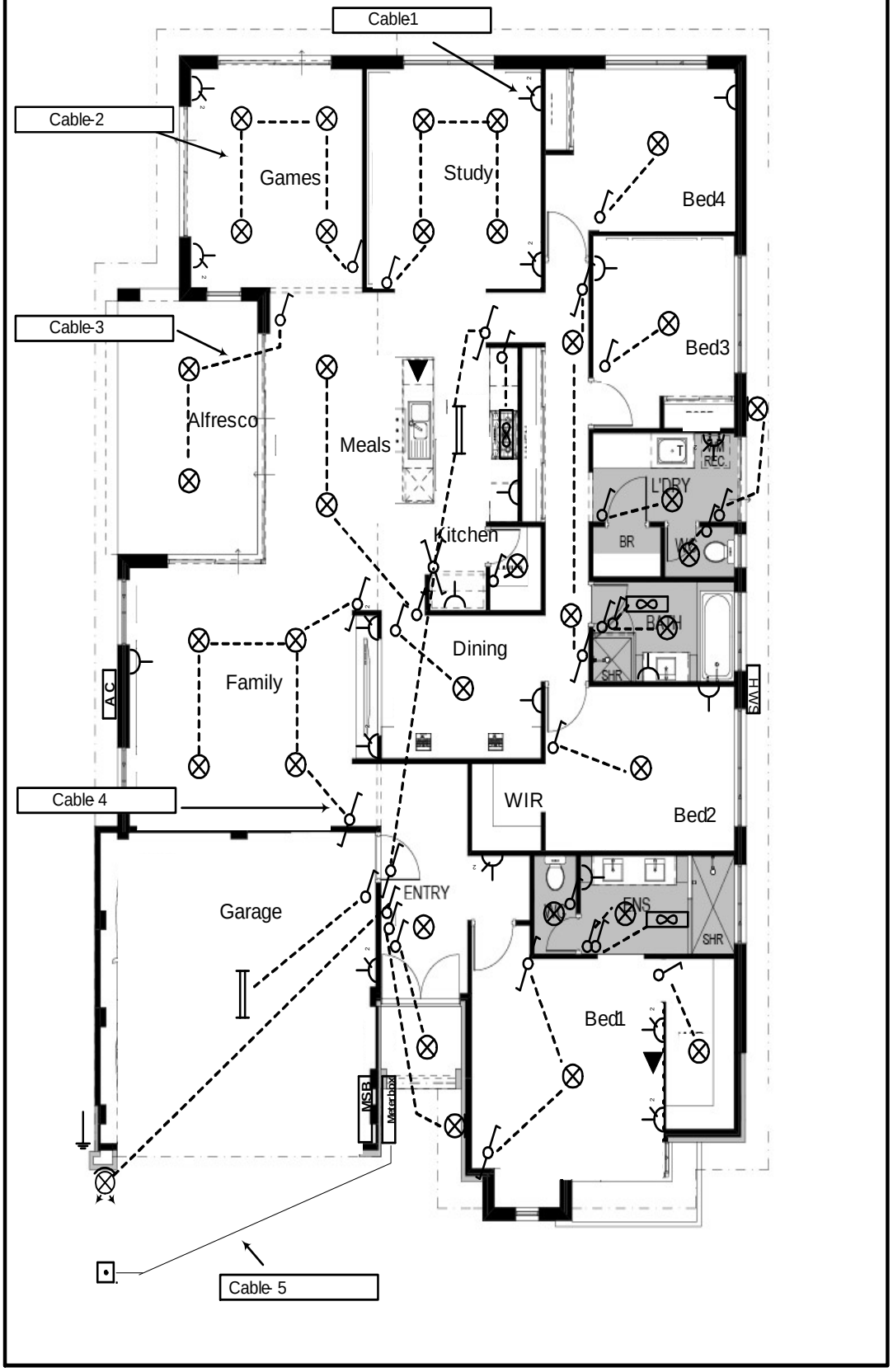
1		11		21		31	
2		12		22		32	
3		13		23		33	
4		14		24			
5		15		25			
6		16		26			
7		17		27			
8		18		28			
9		19		29			
10		20		30			

Figure 1 Floor Plan



The following questions relate to the Floor Plan on **page 31**.

25. The client has requested the light switch for the bedroom 2 luminaire, be moved to the wall on the lock side of the door. i.e. on the same wall as the socket outlet. Mark up the floor plan drawing to show this “as installed” alteration.

26. Locate and mark the service point of supply.

27. Locate and mark the consumers mains cable.

28. Locate and mark the telephone points.

29. Bedroom 2 is actually 3.2m long. Measure the length of bedroom 2, on the floor plan, and calculate the scale of the drawing.

30. What three different types of electrical appliances are found on this drawing?

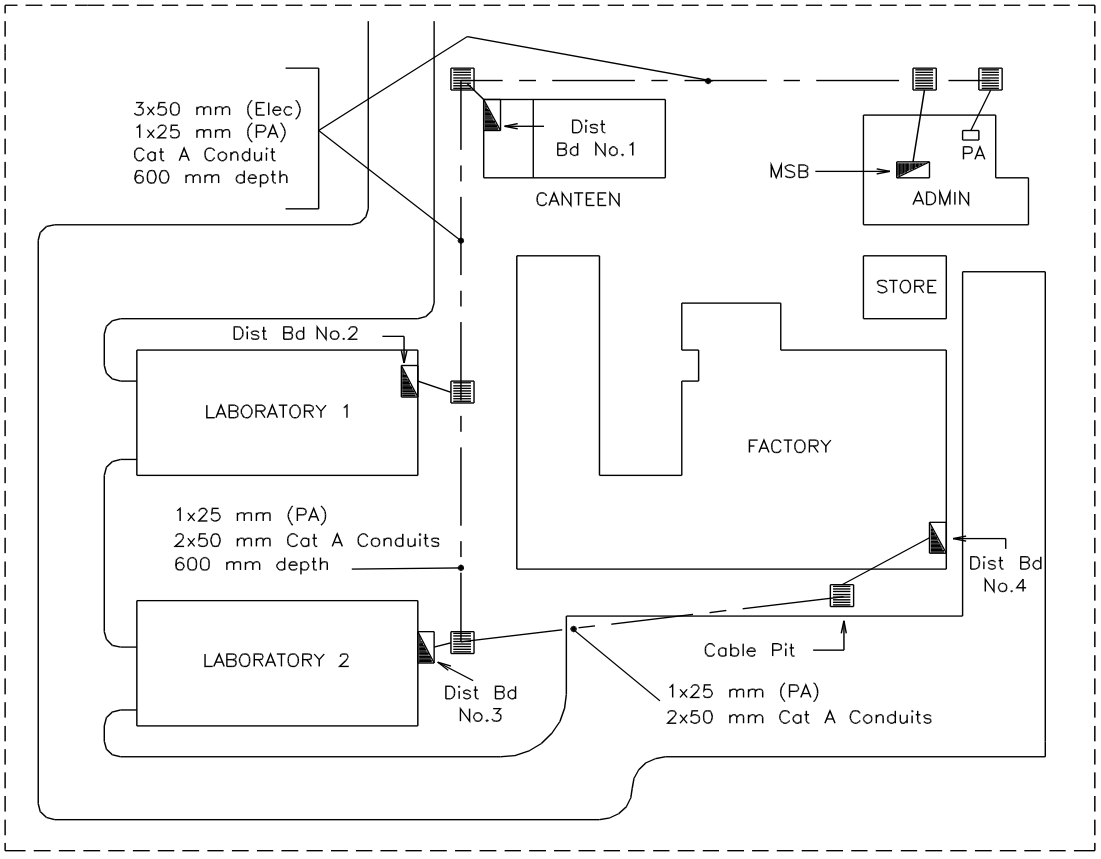
31. Should the size of individual electrical drawing symbols be increased if the overall size of a drawing sheet is increased?

The following questions relate to the Site Plan **below**.

32. Calculate the quantity of 50mm conduit required to run from the centre of the pit outside the Admin to the centre of the pit outside the canteen.

33. Calculate the quantity of 50mm conduit required to run from the centre of the pit outside the Factory to the centre of the pit outside Laboratory 2.

Refer to notes. **Site Plan** **Scale is 500:1**



Electrical Location Symbols
Activity 1-1

Objective

To sketch and label architectural electrical location symbols (on 5 mm graph paper, freehand in pencil using a ruler or circle stencil as required) to AS/NZS 1102.

Equipment

5 mm graph paper
A comprehensive selection of electrical accessories (minimum 10)
Architectural electrical location symbols to AS/NZS 1102
Multimeter or continuity tester

Procedure

1. Select an accessory from the range provided and if necessary use the multimeter or continuity tester to locate any internal connections.

2. Refer to the location symbol sheet and select the correct symbol.

3. Record the name of the component and sketch the symbol (to size) on the 5 mm graph paper.

4. Using the above procedure identify and sketch the symbol for each accessory nominated by the lecturer.

5. Present the completed symbols as part of your folio.

Assessment (Electrical Location Symbols):

Satisfactory:		Not Satisfactory:	

Lecturer: _____ Date: _____

Item number	Description	Symbol
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		

Project Home Electrical Layout
Activity 1-2

Objective

To design the electrical layout of a project home given the consumer's electrical requirements, using Australian Standard 1102 electrical location symbols.

Equipment

Project home floor plan (on A3 size paper if possible)
Consumer's electrical requirements
Australian Standard electrical location symbols

Procedure

1. Select the correct symbol and location for each item specified by the consumer.

2. Sketch the symbol, to size, in the correct position on the floor plan.

3. The connection between a switch position and a luminaire or appliance is shown by a dashed line.

4. Insert a legend to your drawing.

5. Present the completed layout as part of your folio.

Assessment (Project Home Layout):

Satisfactory:		Not Satisfactory:	

Lecturer: _____ Date: _____

Consumer's Electrical Requirements - Project Home

Car Port

1. 1 36 Watt fluorescent, two way switched from entry and car port wall.
   l Double 10 amp single phase outlet, centre car port wall.

Living

2. 1 Centre light, switched from pillar and controlled by dimmer.
   3 Double 10 amp outlets, one in each corner of the interior cavity wall.

Porch

3. 1 Eaves mounted light, switched from entry.

Entry

4. 1 Centre light, switched from entry near door.

Dining

5. 1 Pendant light over dining table, switched from dining entrance.
   1 Single 10 amp outlet on cavity wall between windows.

Kitchen

6. 1 36 Watt fluorescent, centre mounted, switched from entrance to family room.
   1 18 Watt fluorescent, over sink, switched from cavity wall over serve.
   1 Double 10 amp outlet over serve.
   1 Double 10 amp outlet above bench adjacent to hot plates.
   1 300 mm exhaust fan over hot plates, switch adjacent to outlet.
   1 10 amp outlet for fridge.

Family

7. 1 Double 65 Watt fluorescent, centre mounted, switched from entrance to family room.
   1 Double 10 amp outlet on cavity wall.

Laundry

8. 1 Ceiling light centre mounted, switched from entrance to laundry from family room.
   1 External wall light adjacent to laundry door, switched from inside door.
   1 10 amp outlet for washing machine. (consider AS/NZS 3000 clause 6.2.4.2)

Bed 2 - 4

9. 1 Centre light switched from door.
   1 Double 10 amp outlet below window.

Bed 1

10. 1 Centre light, two way switched from passage door and centre of cavity wall adjacent to robe.
2 Double 10 amp outlets on cavity wall one 1 m from robe, and 1 m from corner.

Bathroom

11. 1 Centre light switched from door.
1 Single 10 amp outlet near basin.
1 300 mm exhaust fan switched from entrance.

W.C.

12. 1 Centre light switched from door.
1 200 mm exhaust fan switched from door.

Passage

13. 1 Two lights, 3 way switched both ends of passage and in the centre.
One light mounted on ceiling opposite cupboard, one mounted on ceiling near arch.

En-suite

14. 1 Centre light switched at door.
1 200 mm exhaust fan switched at door.
1 10 amp outlet adjacent to basin.

Consumer's Mains Entry Box

15. Underground supply switchboard directly above tap.

Main Earth

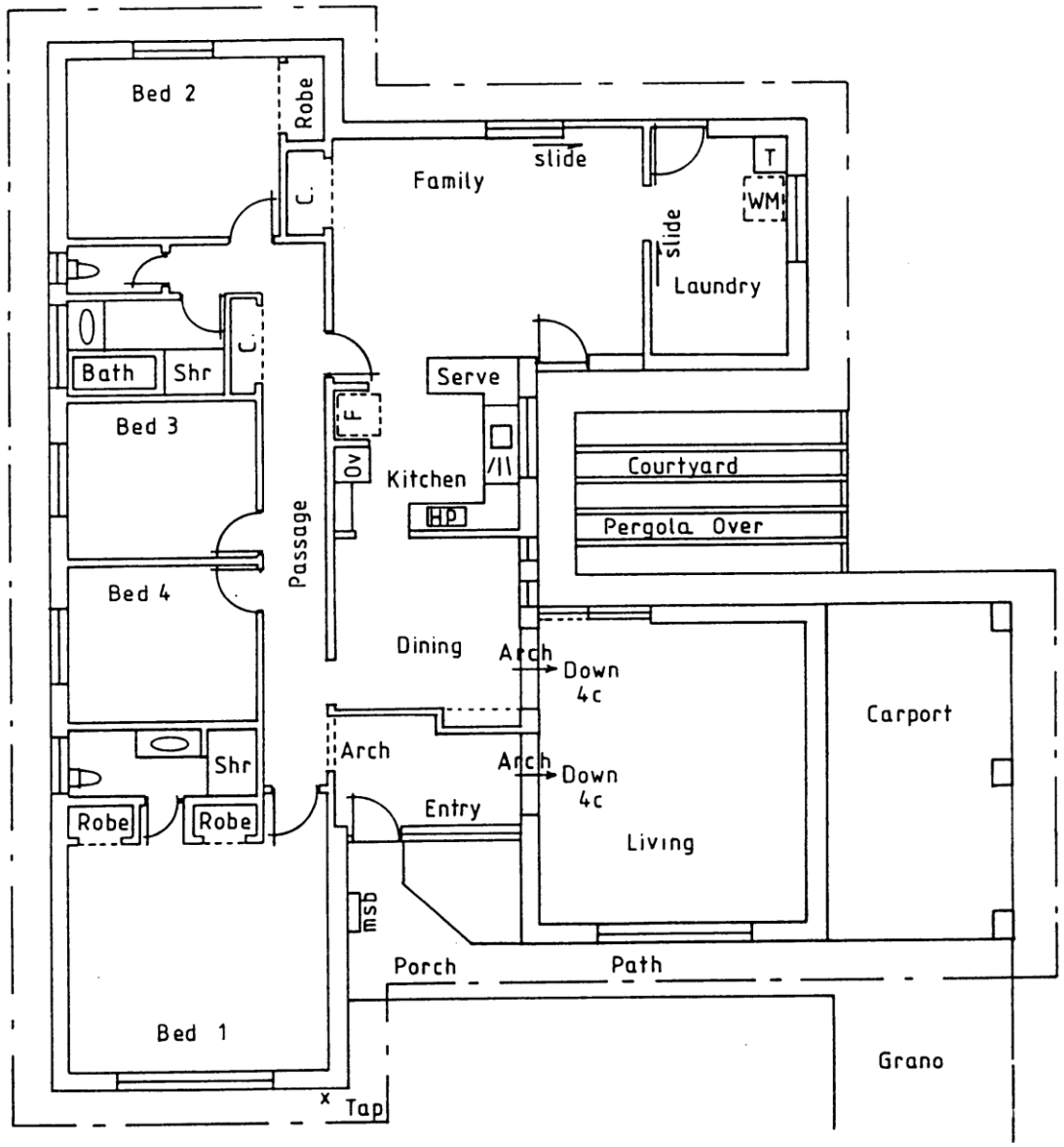
16. Adjacent to tap.

Main Switchboard

17. At entrance on porch wall.

18. Smoke detector in passage. (to be added)

Project Home



Use of Measuring Equipment
Activity 1-3

Object:

To take measurements using a steel tape measure and a laser measuring device.

To apply these measurements to a drawing and calculate the scale.

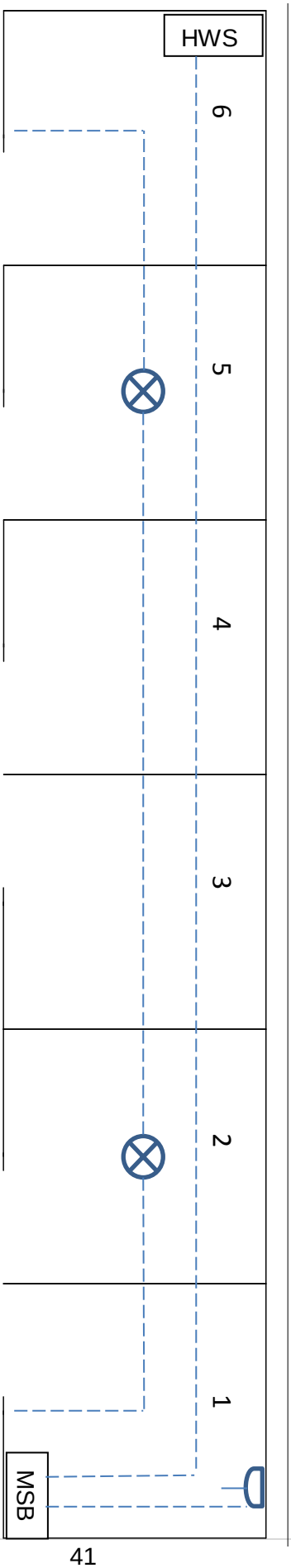
Use the scale and measurements taken from the drawing to estimate cable lengths for a specified installation. **NOTE** Drawing is based on cubicle on site at Balga campus. Individual campuses will need to designate an area to be measured.

Equipment:

- Laser measuring device
- Steel tape measure
- Site plan
- Calculator, ruler and note book.

Procedure:

- Correctly mark up your drawing, to show the appliances/accessories to be installed, using the following installation specifications–
- A 10A socket outlet is to be located on the right-hand side of the rear wall of cubicle 1. It is to be mounted at 300mm AFFL.
- A Hot Water System is to be located to the left-hand side back corner of cubicle 6. It is to be mounted at 1500mm AFFL.
- One light in the centre of cubicle 2 and one light in the centre of cubicle 5. These lights will be operated at the same time, with a two way switch located next to the MSB and the other two way switch located on the left-hand side of the entrance to cubicle 6. The switches will be mounted at 1300mm AFFL.
- Select the most logical cable route, taking into consideration cost of cable versus ease of installation in minimising labour costs. Mark up your drawing to show the cable routes selected.
- Allow for vertical drops and a 0.5m tail at each appliance/accessory for termination purposes.
- Use 4mm^2 cable for the HWS circuit, 2.5mm^2 cable for the socket outlet circuit and 1.5mm^2 cable for the lighting circuit.
- Lecturer to demonstrate features and use of a laser measuring device and the use of a tape measure.
- Take measurements using both measuring devices, for the cable routes drawn on their plan, and compare the two methods.
- Which device do you believe is easier to use? Answer_____
- Calculate cable quantities for each cable type required.
- Measure the cable routes on your plan and compare it to the actual cable route measurements taken. Calculate the scale for your drawing.
- Create a cable schedule so the correct quantities can be ordered.



Cable schedule:

Cable function	Cable type	Quantity

Floor Plan - Electrical Layout
Activity 1-4

Objective

To identify the type, number and location of all electrical items found on a given detailed floor plan containing an electrical layout.

Equipment

Detailed floor plan with electrical layout

Procedure

1. Refer to the floor plan (Figure -1) and legend (or AS 1102 Location Symbols) and record the name of each electrical item in the chart below. The list should include:

   a. The power and light outlets.
   b. All permanently connected electrical appliances.
   c. Luminaire switch positions, (eg. single or multi-way)
   d. Luminaires.
   e. Any sub-boards.

2. Count and record the number of each item. Use catalogue provided and record each item

3. Locate the main earth stake and estimate the length of the main earth wire by referring to the dimensions included on the floor plan.

4. Locate the consumer's main and estimate its length by referring to the dimensions included on the floor plan.

6. Present the completed chart and floor plan as part of your folio.

(Floor Plan - Electrical Layout)

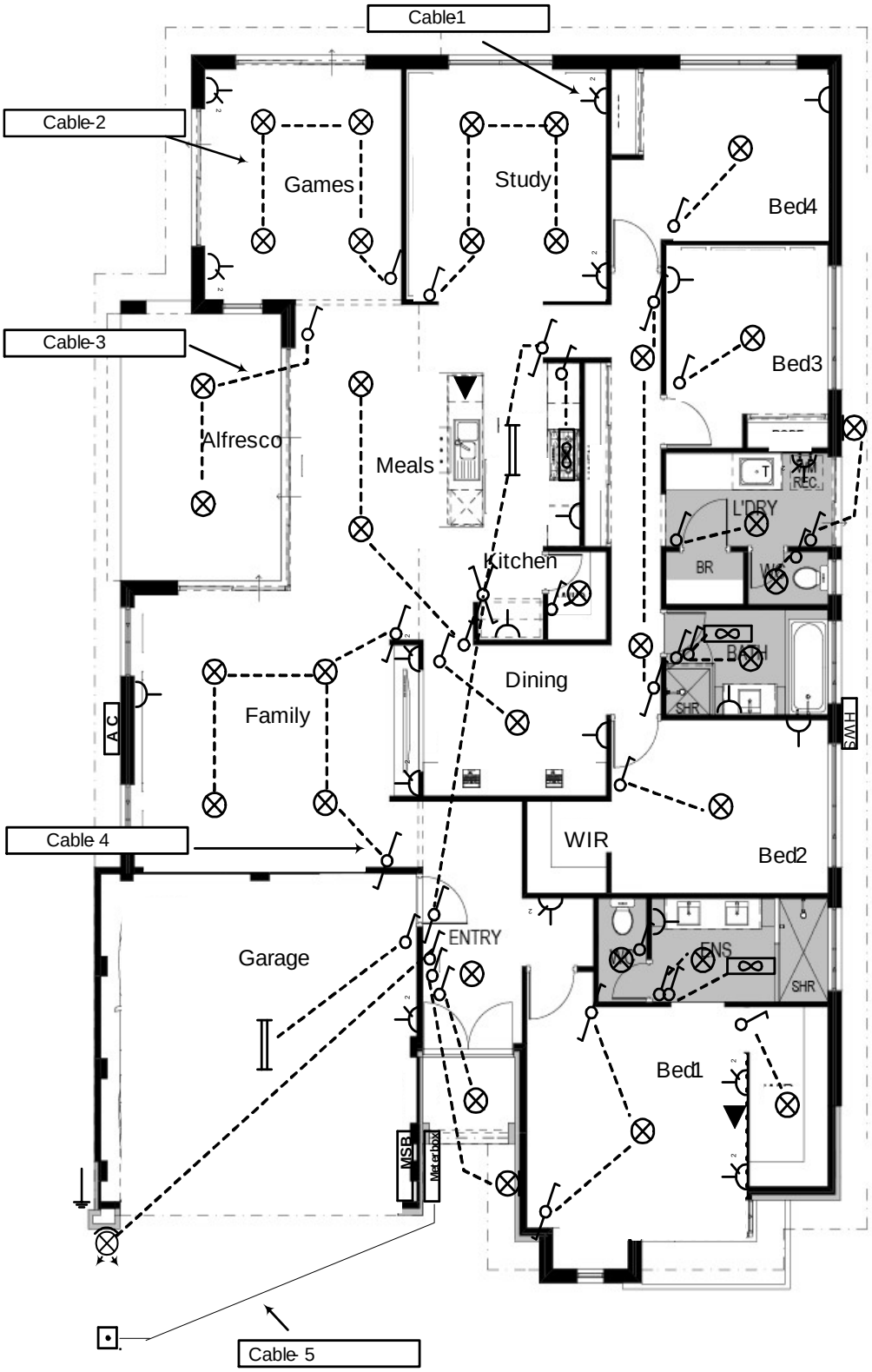
Satisfactory:	

Not Satisfactory:	

Lecturer: _____ Date: _____

No.	ELECTRICAL ITEM	QUANTITY	TYPE OR CATALOGUE No.

Figure 1 Floor Plan



Notes

Electrical Drawings

An electrical diagram is a pictorial representation of an electrical circuit.

Various types are used to convey information to the user, such as how the circuit operates, how the components are connected, or where they are located.

In most cases components are represented by symbols.

Electrical diagrams can be presented in numerous forms, but the three main ones used to show control and power circuits (as distinct from architectural drawings such as floor plans and site plans) are:

a. Block Diagrams.
b. Wiring Diagrams.
c. Circuit Diagrams.

Block Diagrams

A block diagram shows the main sections of a circuit without showing the individual connections between components.

They can provide an outline of the sequence of operation within the circuit and are read from left to right or top to bottom.

A simple example of a block diagram is shown in Figure 1.

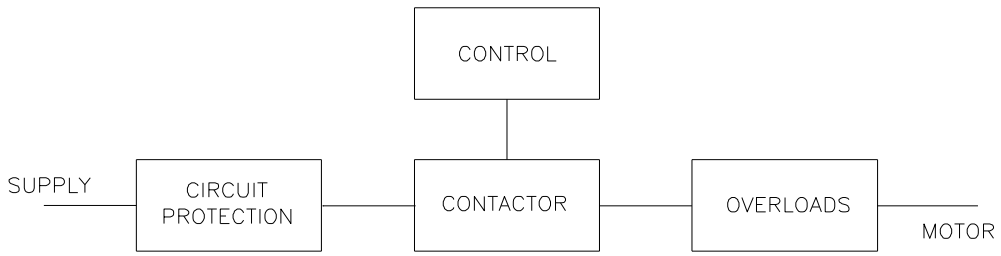


Figure 1 - Simple block diagram

Wiring Diagrams

A wiring diagram shows the physical relationship between the components (not necessarily to scale), and the actual location of the terminals and wiring between them.

All connections are shown at the terminal at which they are made.
An example of a wiring diagram is shown in Figure 2.

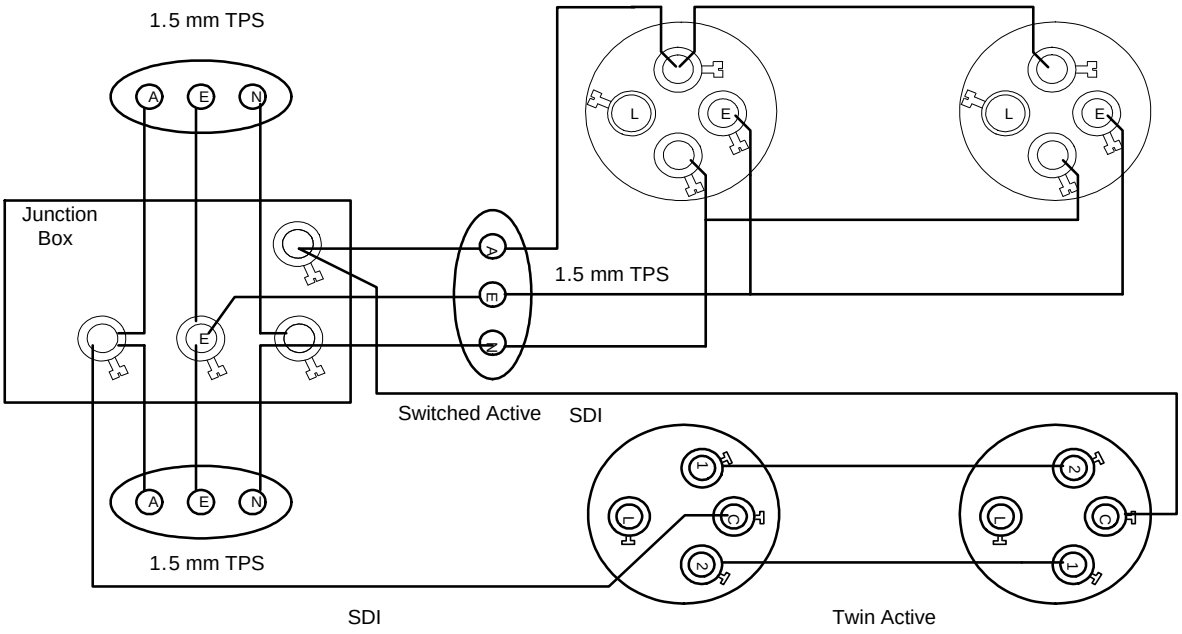


Figure 2 - A sample wiring diagram – 2 Way Lighting Looping at the Junction Box

Typical uses for a wiring diagram include:

a. Checking the actual wiring between components in a piece of electrical equipment.
b. Wiring up a particular piece of equipment.
c. Locating the individual components in a piece of equipment.

Circuit Diagrams

Circuit diagrams show the detailed operation of a circuit in its simplest form.

They are drawn to aid the rapid understanding of how a circuit operates, but they give no indication of the physical position of the components, nor do they give any indication where the conductors actually terminate - all connections are shown in conductors, not at actual terminals.

Circuit diagrams were previously known as 'schematic diagrams'.

Electrical components in circuit diagrams are represented by symbols.

Australian Standard symbols are published in the AS/NZS 1102 series, but there are several different standards throughout the world and some manufacturers use their own standards (or a combination of standard and non-standard symbols) so it is sometimes necessary to work out the meaning of a symbol from its position in the circuit.

An example of a circuit diagram, using Australian Standard symbols, is shown in Figure 3.

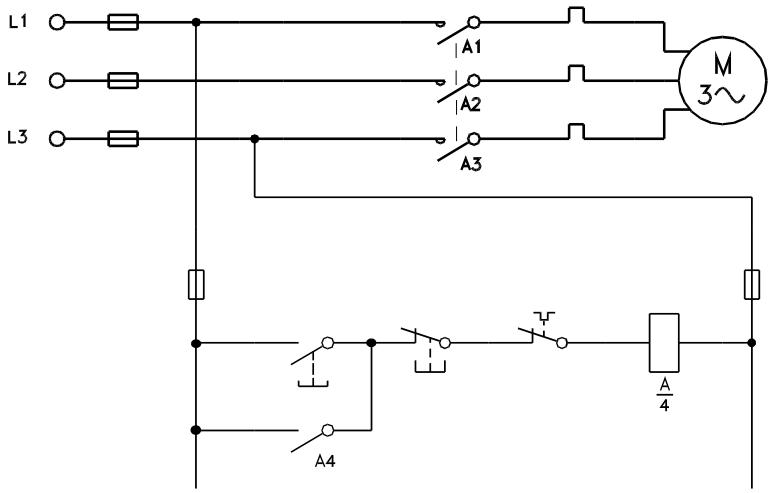


Figure 3 - A sample circuit diagram.

Typical uses for a circuit diagram include:

a. Checking the detailed operation of a circuit.
b. Locating operational faults in a particular circuit or installation using logical reasoning.

Most circuit diagrams use 'detached representation' to show the location of symbols.

In this method the individual parts of a multi-part component (such as a relay coil and its associated contacts) are shown in different locations on the diagram, but they are given labels to show their relationship.

This method results in considerable simplification of the drawing, but it can cause problems when identifying the various parts of a component.

Conventions

In order to be able to read a circuit diagram you need to be familiar with the common drawing symbols, and you need to know the conventions used for presenting information in electrical drawings.

The most important conventions are:

a. All equipment and components are drawn in the **UNOPERATED CONDITION** (i.e. when no current is flowing in the circuit). This convention is most important in circuits involving magnetic relays and contactors.

b. Conductors are represented by **STRAIGHT** vertical or horizontal lines wherever possible - angled lines should only be used where it is unavoidable.

c. All components are represented by symbols - preferably to Australian Standards.

d. Cause and effect is from left to right or top to bottom - the electrical supply is shown on the left or at the top. If the supply is shown on the left, and the sequence of operation is from top to bottom it is called a horizontal arrangement, sometimes being referred to as a "ladder" diagram.

   If the supply is shown at the top, and the sequence of operation is from left to right, it is known as a vertical arrangement.

e. Lines depicting electrical conductors can be of different thicknesses to differentiate between circuits - high current (e.g. power) circuits are often shown with thicker lines than lower current (e.g. control) circuits.

f. Components with specific symbols (e.g. a start button) are not named on the drawing unless to distinguish them from other components of the same type on the same drawing or series of drawings.

   If it becomes necessary to name components it is customary to assign to them a code and then show the full name in a legend (e.g. TDR1 and TDR2 for two time delay relays).

g. Joins between conductors are shown in conductors in circuit diagrams and at terminals in wiring diagrams.

h. Junctions in conductors in circuit diagrams are shown with a dot (with a diameter of twice the line thickness of the conductor). Conductors which cross but are not joined are NOT shown with a loop.

i. Switching components are drawn in such a way that the operation of the moving portion of the switch is in a clockwise direction.

j. The size of drawing symbols remains relatively constant even though the size of a drawing sheet may change.

   A symbol drawn on A4 paper does not double in size if the sheet size is increased to A3.

k. The number of contacts operated by a contactor or relay is shown under the abbreviated name of the contactor or relay coil.

   Actual contacts are labelled with the abbreviation for the contactor or relay by which they are operated, followed by the respective number for that contact.

Electrical Drawing Symbols

The recommended drawing symbols for electrical components are contained in an Australian Standard, AS/NZS1102. This standard consists of a series of standards in numbered parts, each part containing information relative to a particular group of symbols.

Each part is identified with a three digit number which follows the number of the main standard, for example:

a. AS/NZS 1102-103 Conductors and connecting devices.
b. AS/NZS 1102-107 Switchgear, control gear and protective devices.
c. AS/NZS 1102-108 Measuring Instruments, lamps and signalling devices.

Australian Standards are subject to revision to keep up with changing requirements and international trends, so some symbols can change from time to time, therefore electrical workers will often be required to interpret drawings which contain non-standard symbols or symbols based on a superseded standard.

The symbols used in this section generally conform to AS 1102 unless otherwise indicated.

You will not find a standard symbol for every possible electrical device because too many variations are possible.

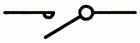
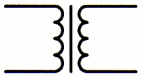
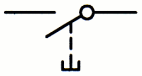
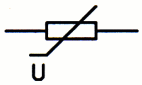
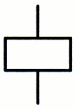
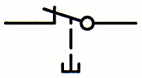
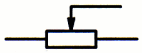
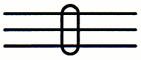
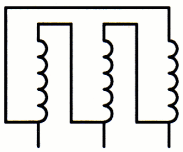
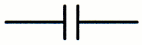
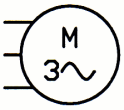
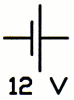
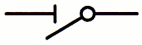
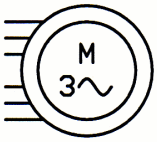
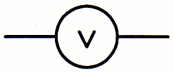
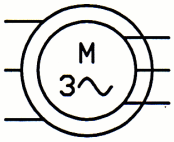
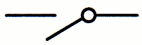
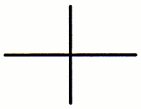
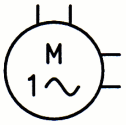
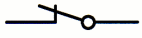
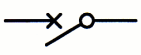
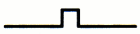
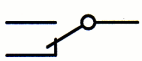
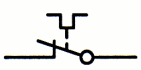
Although the standards include many specific symbols, they often provide a general symbol, a series of 'qualifiers' which are intended to enable users to add to the general symbol to create a symbol for a particular purpose, and examples of how the qualifiers can be used to create other symbols.

The electrical location symbols used in architectural drawings such as floor plans and site plans are not the same as those used in control and power circuits.

Samples of common standard control or power circuit diagram symbols are attached.

ELECTRICAL CIRCUIT DIAGRAM SYMBOLS

Symbol Sheet 1

1		11		21		31	
2		12		22		32	
3		13		23		33	
4		14		24		34	
5		15		25		35	
6		16		26		36	
7		17		27		37	
8		18		28		38	
9		19		29		39	
10		20		30		40	

Symbol Legend
(As per AS/NZS 1102.107:1997)

1	**RESISTOR**	**21**	**NORMALLY OPEN CONTACTOR CONTACT**
2	**VARIABLE RESISTOR**	**22**	**WINDING or MOTOR COIL**
3	**VOLTAGE DEPENDENT RESISTOR**	**23**	**CONTACTOR or RELAY COIL**
4	**POTENTIOMETER (Variable Resistor)**	**24**	**GENERATOR**
5	**CAPACITOR**	**25**	**3 PHASE MOTOR (3 Terminals)**
6	**SINGLE POLE ISOLATOR**	**26**	**3 PHASE MOTOR (6 Terminals)**
7	**NORMALLY OPEN CONTACT or SWITCH**	**27**	**3 PHASE WOUND ROTOR MOTOR**
8	**NORMALLY OPEN CONTACT or SWITCH**	**28**	**SINGLE PHASE MOTOR**
9	**NORMALLY CLOSED CONTACT or SWITCH**	**29**	**THERMAL OVERLOAD HEATER/SENSOR**
10	**TWO-WAY SWITCH**	**30**	**THERMAL OVERLOAD CONTACT**
11	**NORMALLY OPEN TIME DELAY CONTACT**	**31**	**SINGLE PHASE TRANSFORMER (Double Wound)**
12	**EARTH SYMBOL**	**32**	**START BUTTON CONTACT (Normally Open)**
13	**3 PHASE CABLE (3 conductors)**	**33**	**STOP BUTTON CONTACT (Normally Closed)**
14	**3 SHEATHED CONDUCTORS**	**34**	**3 PHASE TRANSFORMER (Delta connection)**
15	**TERMINAL**	**35**	**12V BATTERY or DC SOURCE**
16	**CONDUCTORS – TEE CONNECTION**	**36**	**VOLTMETER**
17	**CONDUCTORS – FOUR WAY JUNCTION**	**37**	**LAMP or LOAD**
18	**CONDUCTORS – NO JUNCTION (Crossover)**	**38**	**FUSE**
19	**SINGLE POLE CIRCUIT BREAKER**	**39**	**LIMIT SWITCH (Normally Open)**
20	**CLOSED LINK**	**40**	**N/C TIME DELAY CONTACT (Delay on opening & Delay on Closing)**

Worksheet 2-1

1. What is the MOST important convention which must be known when reading an electrical circuit diagram?

2. Which type of electrical drawing shows the OUTLINE operation of a circuit?

3. If a particular electrical circuit diagram shows some conductors as thick lines and others as thin lines, what do the THICK lines represent?

4. Which type of electrical drawing shows the actual connections between individual terminals?

5. Should the size of individual electrical drawing symbols be increased if the overall size of a drawing sheet is increased?

6. What type of electrical drawing is most suitable for checking the existing wiring in a circuit?

7. What type of electrical drawing is best suited to showing the DETAILED operation of the circuit?

8. Draw the correct Australian Standard Symbol for each of the following:

    a. stop button

    b. fuse

    c. normally open contact or switch

    d. relay coil

    e. resistor

    f. thermal overload heater element

9. What are two of the main uses for a wiring diagram?

10. What are two of the main uses for a circuit diagram?

11. What two pieces of information can be obtained from a wiring diagram but not on a circuit diagram of the same circuit?

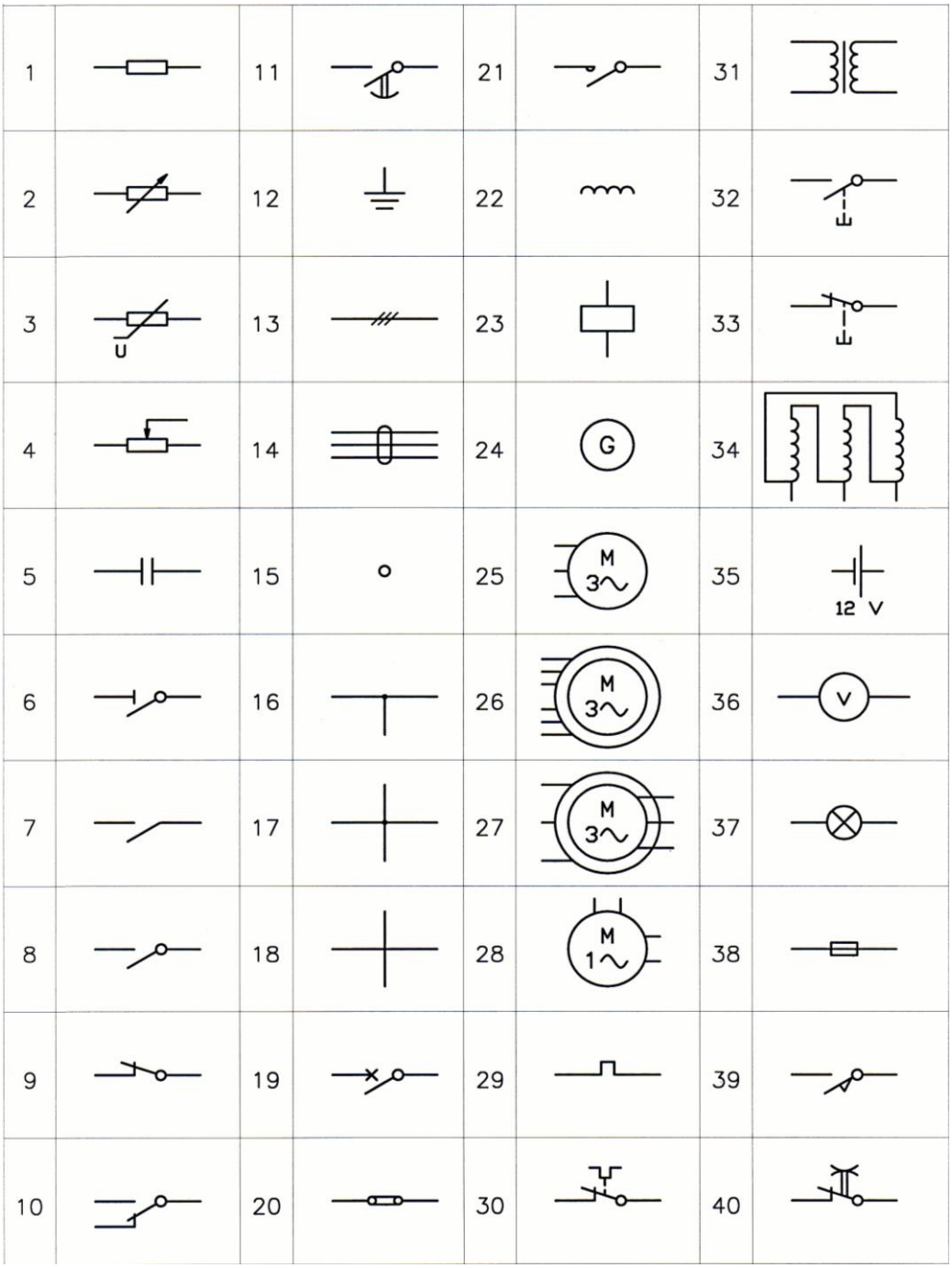
12. Which common type of electrical diagram shows junctions in conductors rather than at specific terminals?

13. What is another common name for a wiring diagram?

14. What is another common name for a circuit diagram?

15. List six of the 'conventions' for drawing of electrical drawings.

16. Identify each of the electrical control drawing symbols on the sheet below.



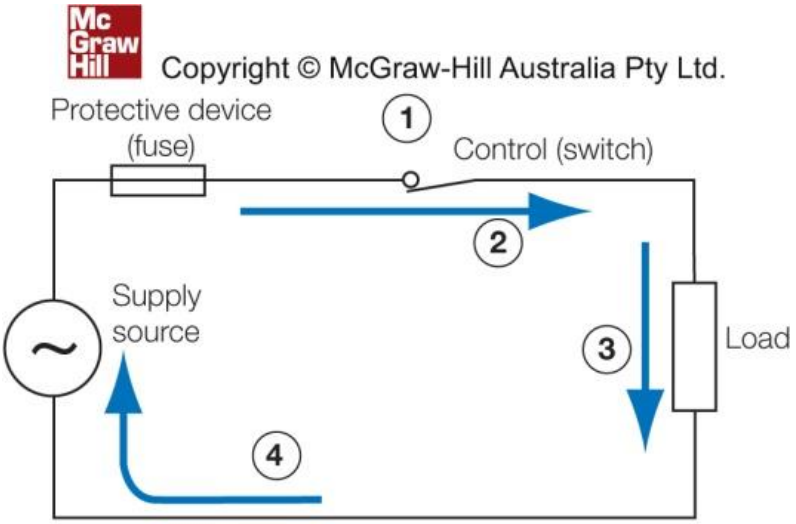
Circuit Diagrams

There are only two basic circuit connections—series connection and parallel connection—in any electrical circuit.

A complete circuit might contain many such connections, in combination with various voltages and devices including signal sources, all interconnected; but basically the most involved circuitry consists of a multitude of series and parallel connections.

All electrical circuits comprise a source of supply; some form of protection; some form of control; a load, which converts electrical energy to some other energy form; and return to the source of supply.

Examine this basic circuit arrangement.



1. When the switch is closed, it closes the series loop.
2. Current flows in the circuit.
3. Current flows to the load or consuming device (motor, lamp, etc.), where energy conversion occurs.
4. Current returns to the supply in the closed loop.

In a series circuit, an interruption or open circuit in any path, including the internal circuit of the supply source, will stop the current flow. In a practical circuit, the protective device, usually a fuse or circuit breaker automatically opens the circuit under predetermined fault conditions.

In normal circuits, most of the supply voltage is expended in driving the current through the load.

Where are circuit and wiring diagrams used?

With the aid of a good wiring diagram, even a less experienced person could wire up the circuit. A skilled electrician would use it as a reference for the actual physical layout of a job such as a large control board.

Switching Circuits

A switch is a device for opening and closing (making and breaking) one or more electrical circuits.

Some switches are operated manually, while others, such as time switches, pressure switches and thermostats are automatic.

Types of Switch

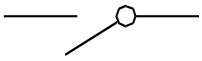
A single pole switch is one suitable for making or breaking a circuit in ONE conductor only.

A double pole switch makes or breaks a circuit in TWO conductors simultaneously, and a triple pole switch makes or breaks a circuit in THREE conductors simultaneously.

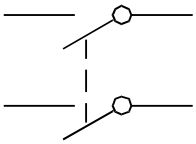
A single throw switch is one which has two possible conditions (e.g. on or off, up or down), and changes its condition with one 'throw' of the switch.

The main types of switch in common use are:

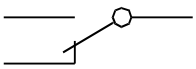
a) **Single Pole Single Throw** (SPST)



b) **Double Pole Single Throw (DPST)**

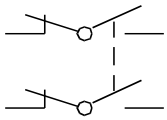


c) **Two Way, or Changeover (SPDT)**

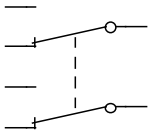


d) **Double Pole Double Throw** (DPDT)

One type

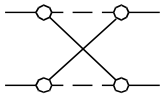


Another type

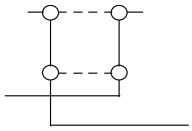


e) **Intermediate**

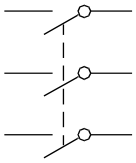
One type



Another type



f) **Triple Pole Single Throw** (TPST)



A switch can also be classified according to the physical mechanism used to make or break the circuit. Typical formats include:

a. Rocker switches.

b. Toggle switches.

c. Tumbler switches.

d. Slide switches.

e. Push button switches.

f. Thumbwheel switches.

Other types of switches are available for specific purposes, such as three heat switches on urns, micro switches, and limit switches.

Switch Ratings

Each switch has a maximum voltage and current rating which must not be exceeded. These values are usually marked on the body of the switch.

AC switches must not be used on the same current DC because DC draws out a much greater arc, and electrical fires can result.

Locating Internal Connections

The internal connections (or bridges) in a switching device can be located using any type of circuit continuity tester such as battery test lamp, ohmmeter, multimeter, or series test lamp. A typical procedure is as follows:

a. Draw a sketch of the physical position of the connecting terminals on the switch.
   Note whether the sketch is a view from the front or the back of the switch.

b. Check the continuity tester for correct operation.

c. Remove external wiring from the switch (to avoid false readings), marking each wire as you remove it.

d. Check for continuity between EVERY POSSIBLE PAIR of terminals in each switch position. If continuity is indicated, show it as a bridge between the two terminals on your sketch, and indicate the appropriate switch position. Many switches have more than one pair of terminals bridged in each position. For multi position switches it is advisable to draw a separate sketch for each switch position.

e. When you have drawn the sketch, repeat the procedure to make sure you have not made a mistake.

f. Replace the external wiring in its correct place.

Switching Charts

Switching charts are designed to give information about the internal connections for each position of the switch.

This information is presented in a Table as shown in Figure 1.

The X represents a bridge between the terminals listed, for the switch position specified.

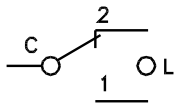


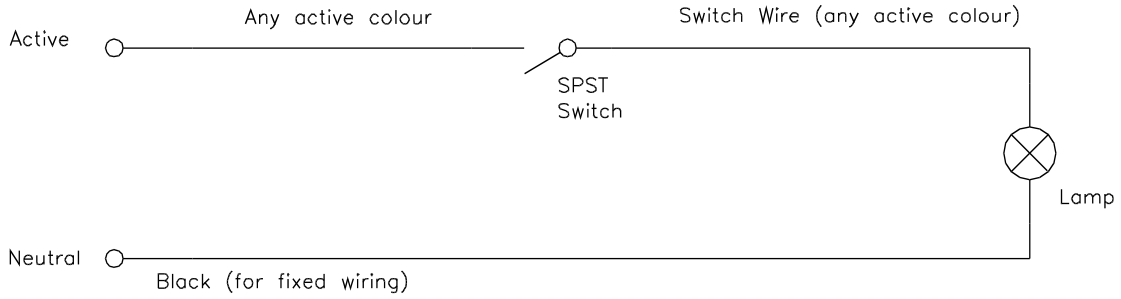
Fig 1. Two-way Switch

Terminals	Toggle Up	Toggle Down
C–1		X
C–2	X	
C–L		
1–2		
1–L		
2–L		

Switching Circuits

A single pole a.c. switch must be connected so that it switches the ACTIVE conductor in the circuit in which it is connected. (AS/NZS 3000:2018 Clause 2.3.2.1.2(a))

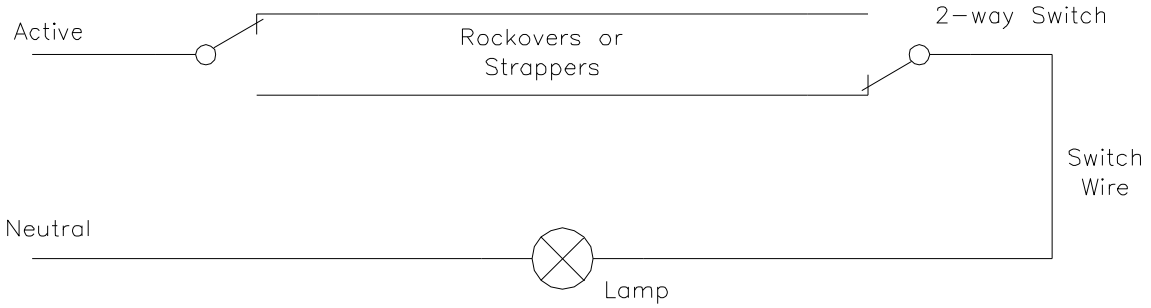
Single Way Lighting Circuit A single way lighting circuit is one in which a lamp is turned on or off from one switch position. The wiring must be colour coded according to the Wiring Rules (see Clause 3.8). An 'active colour' in a fixed installation wiring is any colour other than black, light blue, green, yellow, or a green/yellow combination. A typical single way circuit controlling one lamp is shown below:



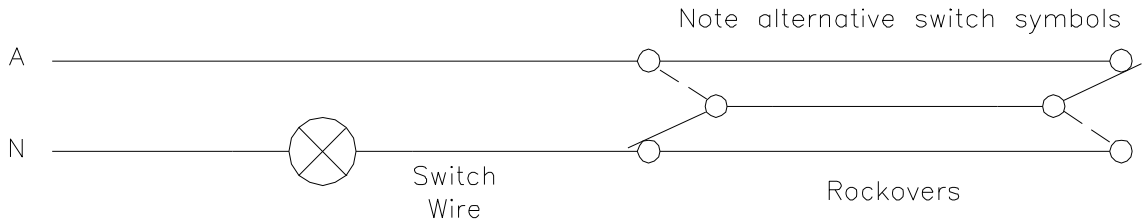
Note: Luminaires with exposed metal must be earthed unless they are double insulated.

Two Way Lighting Circuit A two way lighting is one in which one or more lamps can be switched on or off from either of TWO switch positions.

a. Method 1

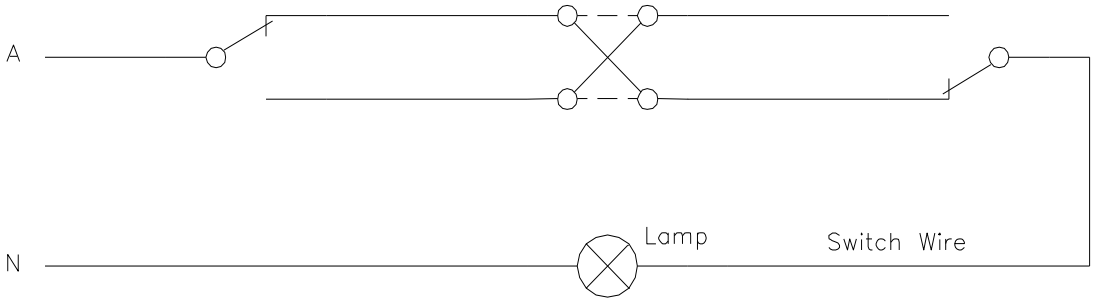


b. Method 2

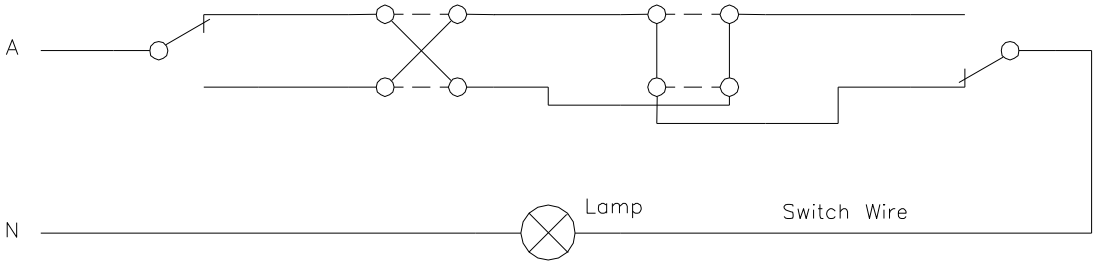


Note: The lamp must never be connected in any one of the rockovers.

Three Way Lighting Circuit A three way lighting circuit is one in which one or more lamps can be switched on or off from any one of three switch positions. A three way circuit requires two two-way switches and one intermediate switch.



Multi Way Lighting Circuit A two way lighting circuit can be modified so that one or more lamps can be switched on or off from any number of switch positions by adding extra intermediate switches. The following circuit shows a four way lighting circuit in which two different types of intermediate switch have been used.



Methods of Wiring

There are two general methods of wiring the lighting circuits in an installation:

a. By looping at the light.
b. By looping at the switch.

Looping at the Light Method of Wiring

This is the most common method of wiring, and requires the Active, Neutral, and Earth (usually as a TPS cable) to be taken to each light point, and a twin active cable from this point to the switch position. The circuit is then connected as shown in Figure 1.

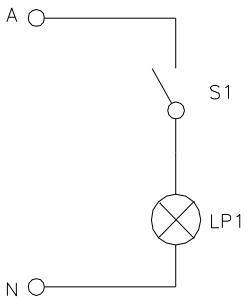


Fig.1 Circuit Diagram for a single light point

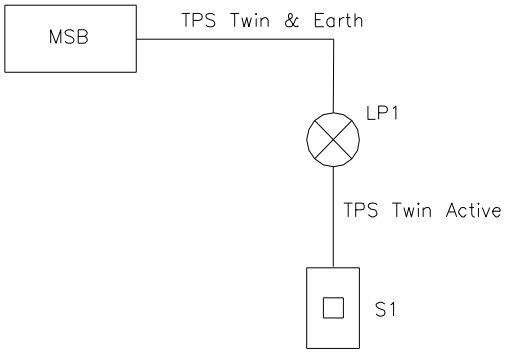


Fig.2 Cabling Arrangement for Fig.1

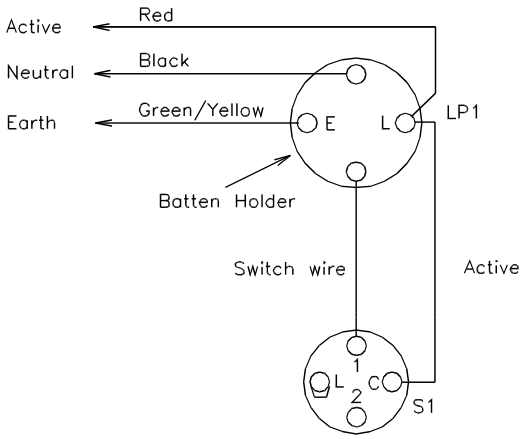


Fig.3 Wiring Diagram for Fig.1

For subsequent lights the twin and earth cable is looped from light to light, and a twin active is taken from each light to its switch, as shown in Fig.4

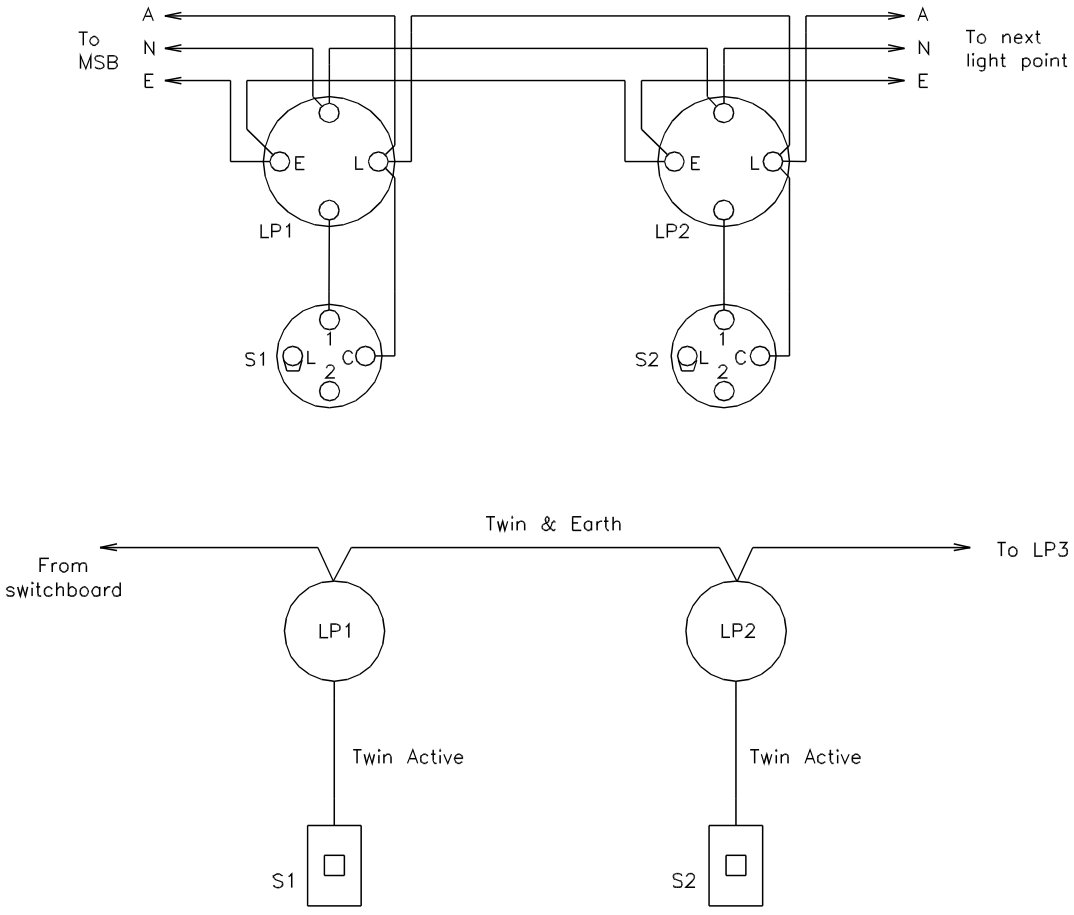


Fig.5 Cabling Arrangement - Looping at the Light.

Multi Position Switching.

18. For more than one switch to control a light, the twin and earth cable is looped to each light point as before, but the switching circuit changed as shown in Figs.6 and 7.

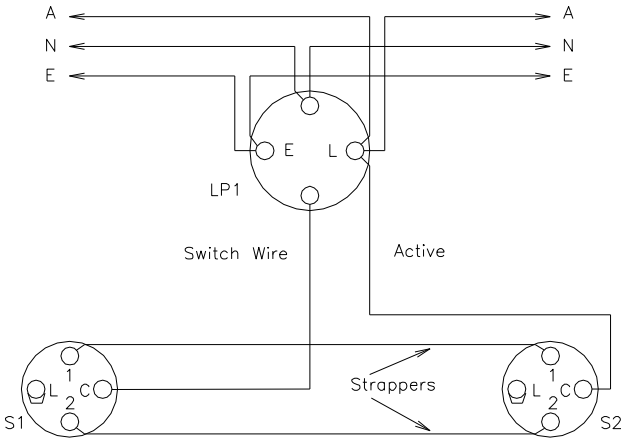


Fig.6 Wiring Diagram - Multi Way Circuit.

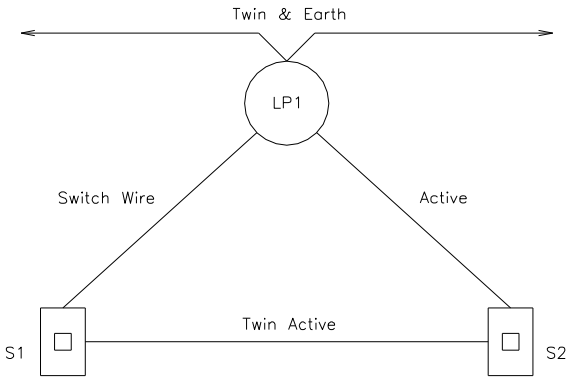


Fig.7 Cabling Arrangement - Multi Way Circuit.

Looping at the Switch Method of Wiring.

This is an alternative to the looping at the light system, and requires the Active, Neutral, and Earth to be looped from one switch position to the next. A twin and earth cable is then taken from each switch to the light that it controls.

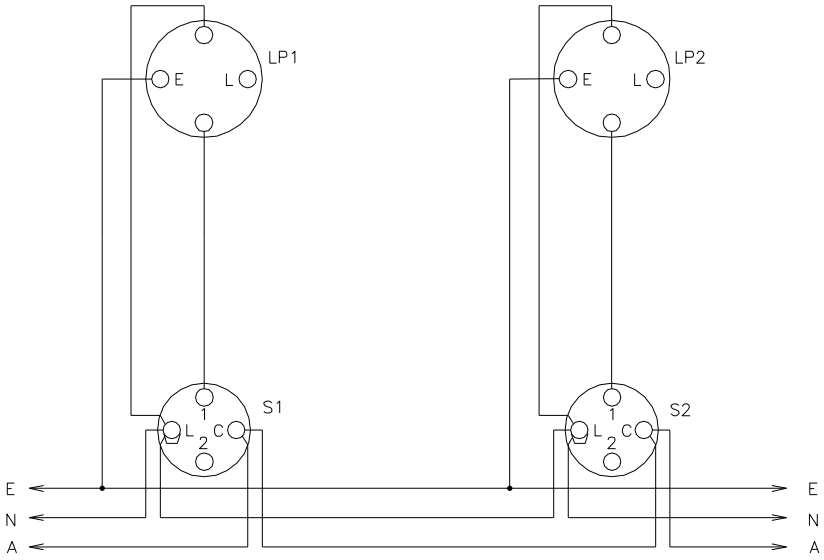


Fig.8 Wiring Diagram - Looping at the Switch.

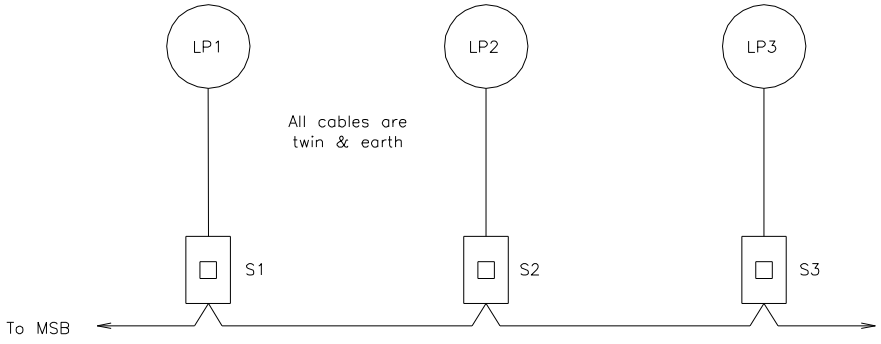


Fig.9 Cabling Arrangement - Looping at the Switch.

This method of wiring is not used very often as it has several major disadvantages.

a. The total length of cable is greater to loop to switches in most situations.

b. All cables must be twin and earth, so cable expense is greater.

c. Where switches are to be fixed to door architraves it is much more difficult to make the terminations.

d. Because of the increased number of cables in the walls, it increases the problems of later installation of additional switches at the same switch position.

Switching Circuits
WorkSheet 3-1

1. Draw the symbol for each of the following electrical switches:

   a. Triple pole - single throw.

   b. Single pole - single throw.

   c. DPST.

   d. Two way.

   e. Intermediate.

   f. DPDT.

2. Draw a circuit diagram in which one lamp can be controlled from either of two switch positions.

3. Draw a circuit diagram in which one lamp can be controlled from any one of five switch positions. Show the colours of the cables in your diagram.

4. Why are double pole switches used on plug in portable heating appliances?

5. What is the sequence for connecting active, neutral and earth in general purpose outlets? State the AS/NZS Clause number.

6. What would be the result if a 240 volt 5 amp 'AC only' switch was used to switch 5 amps direct current.

7. Draw a simple diagram of the "looping at the light" method of wiring lighting points in a domestic installation, using four plate ceiling roses or batten holders.

Switch Identification
Activity 3-1

Objective

To name and sketch (on 5 mm graph, freehand in pencil using a ruler or circle stencil as required), both the symbol and the internal connections for a range of switches provided.

Equipment

5 mm Graph Paper
Multimeter or continuity tester
A comprehensive selection of switches including SPST, SPDT, DPST, DPDT, TPST, TPDT. The switches to include toggle, rocker, slide, micro, push button and rotary switch types.

Procedure

1. Sketch on graph paper the rear view of each of the switches provided. Show the location of all terminals.

2. Record the maker's name, the trade name, current and voltage rating of each switch.

3. Using the multimeter or continuity tester, locate the internal connections of each switch for each position. Sketch the correct internal connections on the rear view of each switch.

4. Construct a Switching Chart for each switch.

5. Sketch the correct symbol, to size, beside the rear view of each switch.

6. Present the completed sketches as part of your folio.

Assessment (Switch Identification):

Satisfactory:		Not Satisfactory:	

Lecturer: _____ Date: _____

Two way Lighting
Activity 4-1

Objective

To convert a two way lighting circuit to a wiring diagram, then connect and test it for correct operation.

Equipment

ELV lighting project board with incandescent lamp
ELV power supply
Continuity tester
Connecting leads

Procedure DANGER TAG PROCEDURE REQUIRED

1. Draw a circuit diagram showing one lamp which can be switched on or off from either of two switch positions. Label each of the conductors with correct names. Use this to produce a wiring diagram to use as a plan to carry out the actual wiring.

Circuit diagram.
Wiring diagram.

2. Identify appropriate switches on the lighting project board using a continuity tester. Convert the circuit diagram to a wiring diagram.

3. Wire the circuit according to your diagram, using appropriate colours for each of the conductors.

4. Check your circuit for short circuits using a continuity tester, then have your project checked by your lecturer.

5. Plug the circuit into the ELV power supply and test for correct operation.

6. Have the operation of the circuit checked by your lecturer.

7. Switch the circuit off, remove the plug from the outlet, then disconnect your wiring and return all equipment to its proper place.

Question

1. Draw a circuit diagram showing how two INTERMEDIATE switches can be used to control a lamp from either of TWO switch positions.

Assessment (Two-way Lighting):

Satisfactory:		Not Satisfactory:	

Lecturer: _____ Date: _____

As electricians become more experienced, they tend to prefer the circuit diagram to the wiring diagram.

It would be almost impossible to design, install or efficiently test complex electrical equipment without the use of a circuit diagram at some stage.

For anyone familiar with electrical work it is easy to trace out and follow a circuit if the wiring is visible, but in the average electrical installation the wiring is concealed within the structure or hidden within equipment.

With the aid of a good circuit diagram, the necessary tests for short circuits, leakage paths, open circuits and malfunction of circuit devices can be performed without dismantling equipment or pulling the installation apart.

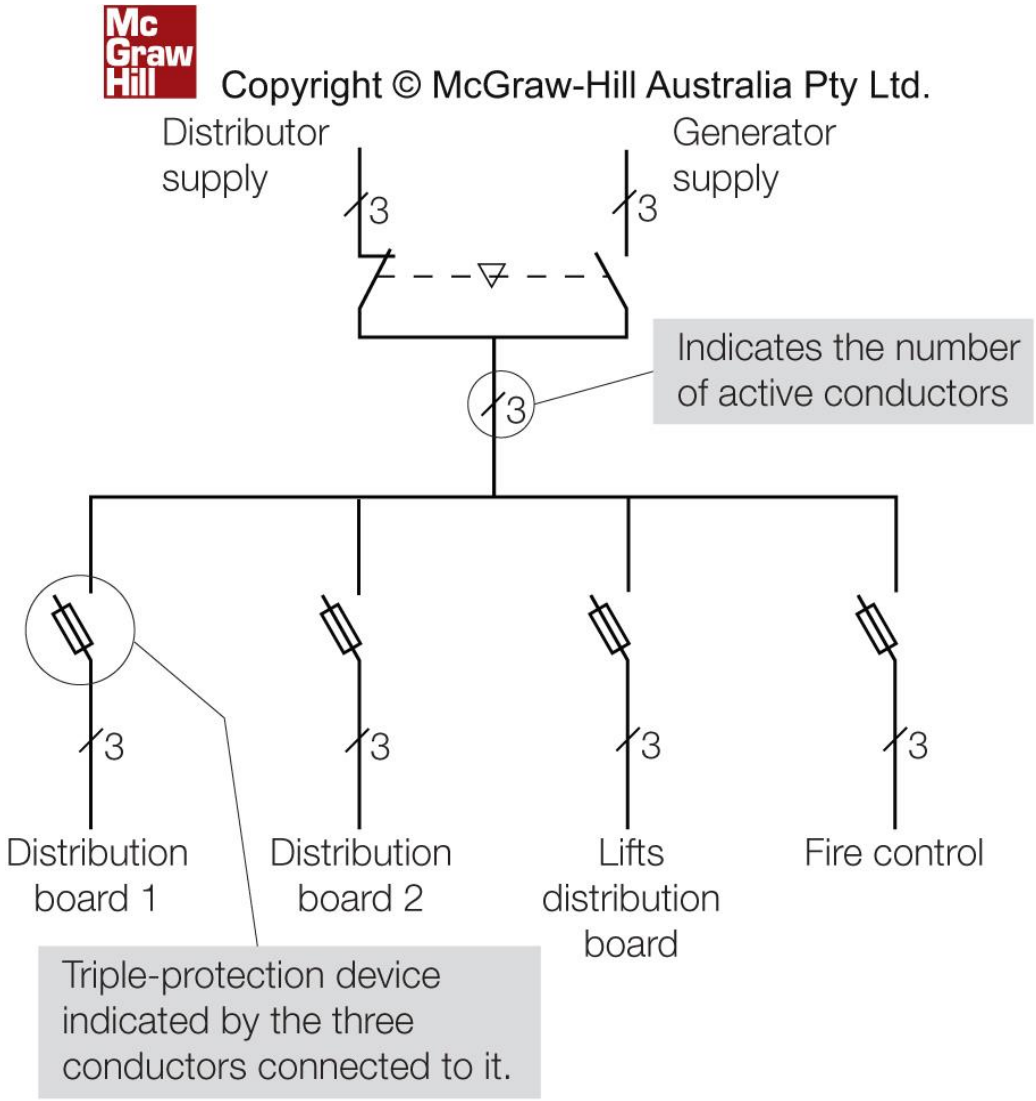
The agreed way of presenting information in electrical diagrams is based on various local and international standards.

Although these may vary, the drawing conventions summarised in Figure 6.2c (over page) provide a basis for interpreting most electrical diagrams.

Other types of electrical diagrams

The single-line diagram is another form of circuit diagram, used mainly to show the arrangement of switching that controls the way equipment is interconnected in power distribution systems and installations.

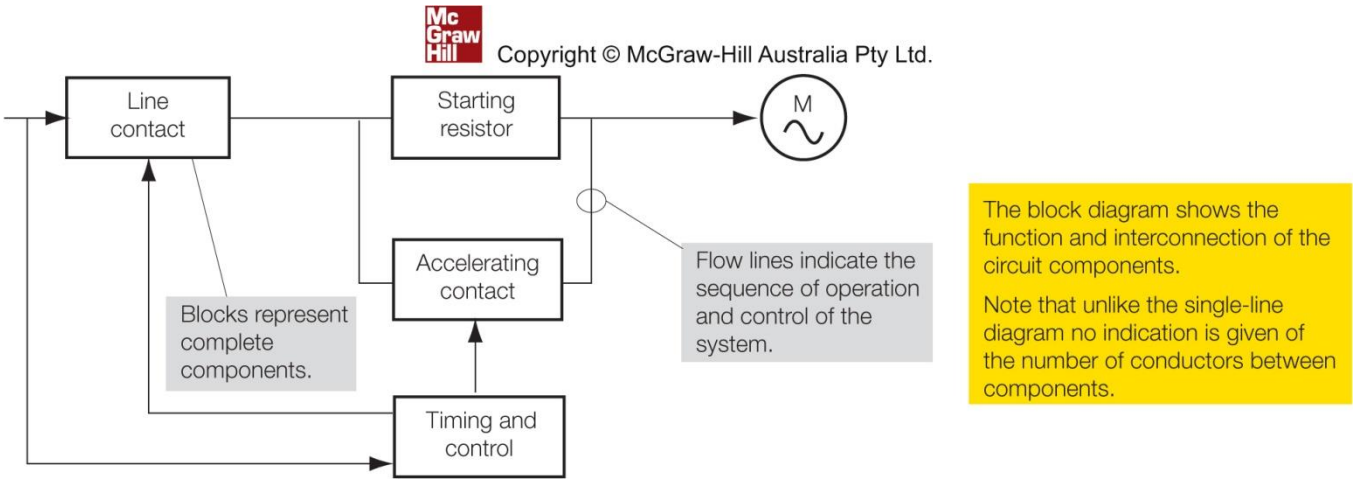
A simple example is shown in Figure 6.2d (p. 142).



Note that neutral conductors and earthing conductors are not shown. In practice any special earthing arrangements are shown on a separate diagram.

In the block diagram, blocks are drawn to represent complete component circuits or elements.

Figure 6.2e (p. 142) illustrates a simple block diagram for a primary resistance starter for an induction motor.



Block diagrams are most useful in the diagnosis of faults and in the design stages of circuits and in installation.

They are widely used in the supply industry, for example, in system diagrams.

Wiring connection tables or cable schedules, as shown in Figure 6.4c (below), are another form of communicating electrical information, and can be easier to follow where many cables and connections are involved.

Accessories schedule

Component	Manufacturer and catalogue no.	Special requirements	Protection rating	Installation
Three-phase socket-outlets	(*To be submitted by contractor*)	Solvent resistant	IP 56	Surface mounted
Isolating switches for maintenance	(*To be submitted by contractor*)	Solvent resistant	IP 56	Surface mounted
Functional switches	(*To be submitted by contractor*)		NA	Flush mounted
Single-phase socket-outlets	(*To be submitted by contractor*)		NA	Flush mounted

Lighting types and illumination schedule

The types of information in this schedule is becoming more common with the adoption of energy efficiency regulations in building design. Contract progress and final payments are test results showing compliance with the specified requirements.

Area	Efficiency (w/m^2)	Type	Illumination (lux)	Completion test (lux)
Lobby	10	CF down lights	150	(*To be completed by the contractor*)
Main office	10	4 × 36W troffers	320	(*To be completed by the contractor*)
Board room	10	CF down lights	320	(*To be completed by the contractor*)
Plant rooms	10	250W CCMV high bay	250	(*To be completed by the contractor*)

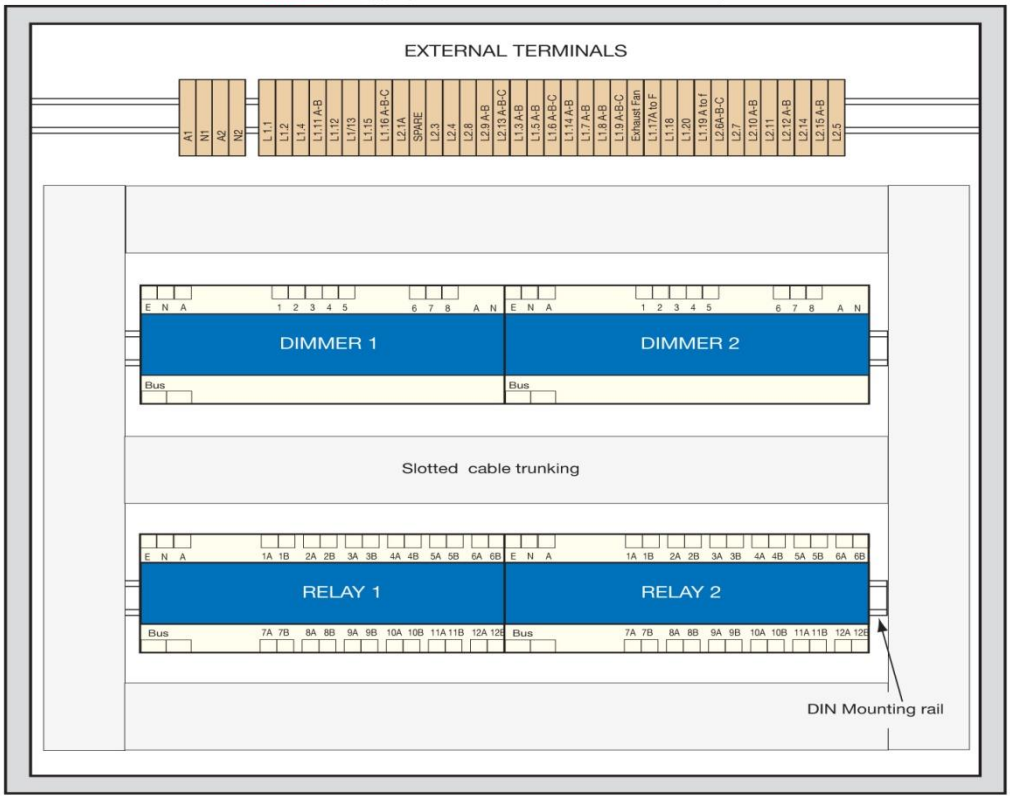
Cable schedule:

Cable schedules are often used in complex installations where many cable are installed and precise cable routes are to be followed such as installations for industrial plants.

Circuit	Cable	From	To (Drawing grid reference)	Route
Pump 1	SWA 16 mm^2 4-core and earth	Load centre 1/1	6-C	Cable tray 1 and vertical unistrut support
Pump 2	SWA 16 mm^2 4-core and earth	Load centre 1/2	7-C	Cable tray 1 and vertical unistrut support
Roller drive	Symmetrical, copper-screened XPLE 35 mm^2 4-core and earth	Load centre 1/3	9-D	Cable tray 2 and vertical structural support
Blower	PVC circular 10 mm^2 4-core and earth	Load centre 1/4	9-A	Cable tray 1 and drop in surface-fixed steel conduit

They are typically used in switchboards and control panels or the point-to-point cabling in large installations.

They are illustrated in Figure 6.2f (p. 143), which shows a panel layout and connection table for a lighting control system.



Dimmer 1 Terminal	External Terminal
A	A1
N	N1
1	L1.1
2	L1.2
3	L1.4
4	L1.11A-B-C
5	L1.12
6	L1.13
7	L1.15
8	L1.16A-B-C
Dimmer 2 Terminal	External Terminal
A	A2
N	N2
1	L2.1A
2	L2.2
3	SPARE
4	L2.3
5	L2.4
6	L2.8
7	L2.9A-B
8	L2.13A-B-C

Relay 1 Terminal	External Terminal
A	A1
N	N1
1A	A1
1B	L1.13A-B
2A	A1
2B	L1.5A-B
3A	A1
3B	L1.6A-B-C
4A	A1
4B	L1.14A-B
5A	A1
5B	L1.7A-B
6A	A1
6B	L1.8A-B
7A	A1
7B	L1.9A-B-C
8A	A1
8B	Exhaust Fan
9A	A1
9B	L1.17A to D
10A	A1
10B	L1.18
11A	A1
11B	L1.20
12A	A1
12B	L1.19A to F

Relay 2 Terminal	External Terminal
A	A2
N	N2
1A	A2
1B	L2.6A-B-C
2A	A2
2B	L2.7
3A	A2
3B	L2.10A-B
4A	A2
4B	L2.11
5A	A2
5B	L2.12A-B
6A	A2
6B	L2.14
7A	A2
7B	L2.15A-B
8A	A2
8B	L2.5
9A	A2
9B	
10A	A2
10B	
11A	A2
11B	
12A	A2
12B	

Circuits in general wiring

The circuits in an installation are categorised by the types of loads they supply. Generally these categories are:

- lighting
- power (socket-outlets)
- mixed circuits supplying both lighting and socket-outlets
- permanently connected appliances, which include motors and composite machines
- sub-mains supplying distribution boards, the load being the combination of all loads supplied from the distribution board.

The actual wiring of circuits, that is, the locations from and to where wiring is run, will depend on the location of the load (the parallel component) in relation to its control devices (the series components).

The various cable routes through different types of building structures are discussed in Chapter 7; for now, the emphasis is on the importance of planning the wiring.

It would be embarrassing for an electrician at the final connecting stage (fitting out) of an installation, when most building finishes have been completed, to find they are short of a cable core at a connection point.

A little time spent planning will go a long way towards avoiding this type of situation, and planning is never more critical than for lighting circuits.

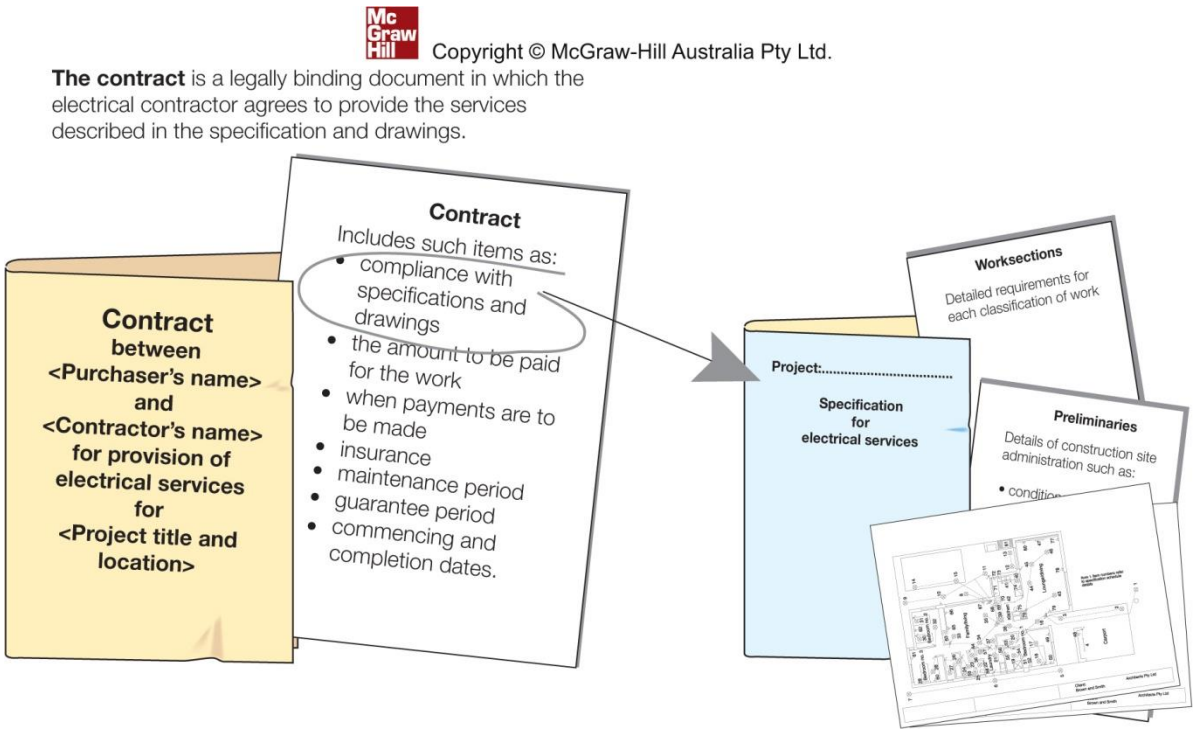
Undertaking electrical work

The electrician is called upon to undertake a variety of electrical work, including servicing and maintenance, attending to electrical breakdowns, making alterations or additions to existing installations and new installation work.

No matter what type of work, for it to be completed successfully a business relationship between the electrical contractor and their client/customer is needed. This is typically done through a contract between the parties that covers the scope of the work, its cost, the time for the work to be completed, and how and when payment for the work is to be made.

Within the contract, references are made to technical documents, that is, ‘specification’ with ‘schedules’ and ‘drawings’.

These documents (see below) inform the electrician of the details of the work to be done.



The contract between the client/customer and the electrical contractor for the supply of service described in the specification (and drawings) also includes terms of payment, indemnity, liquidated damages, maintenance period, extending of guarantees, and commencing and completion dates.

Specifications for electrical work

The electrician is called upon to undertake a variety of electrical work, including servicing and maintenance, attending to electrical breakdowns, making alterations or additions to existing installations and new installation work. No matter what type of work, for it to be completed successfully a business relationship between the electrical contractor and their client/customer is needed.

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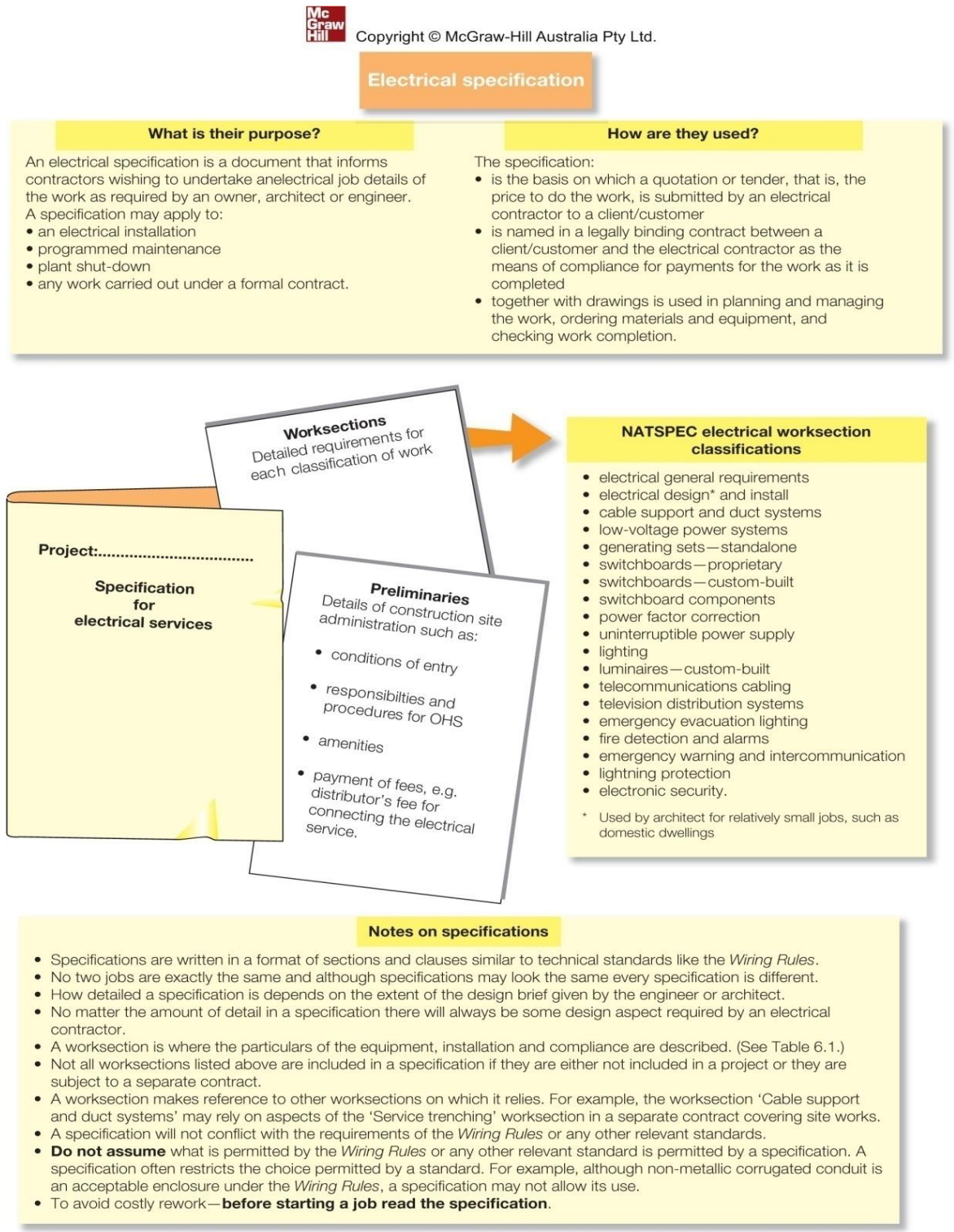
Within the contract, references are made to technical documents, that is, 'specification' with 'schedules' and 'drawings'.

The figure below outlines the purpose of electrical specifications, how they are used and the main sections of a typical specification.



Although a specification may apply to an installation, a maintenance program, a plant shut-down or any other contracted work, the focus here is on installation work. Mastering the use of specifications for installation jobs will equip you to handle specifications for most other kinds of work.

The level of detail of information that is given in a specification increases with the complexity of the work.

For example, the specification for a small job, say, the renovation of a typical suburban house, may only consist of general instruction from the owner or builder.

In such cases it is important that the electrician obtains agreement on the location of lighting points and switches, socket-outlets and fixed appliances from the owner/builder and marks them up on a copy of the builder's plan.

In the same way, the types of lighting control, general accessories and luminaries should be listed and signed as agreed to before the work is commenced.

The number of circuits, wiring systems, cable sizes, protection, switchboard arrangements and the like are left to the electrician to determine, remembering that the installation must comply with the Wiring Rules and local service requirements.

In larger and more prestigious jobs, a specification is likely to detail the types of wiring and wiring methods to be employed, luminaries, types and positioning of accessories, number of circuits and the types of circuit protection needed.

As a general rule, jobs where the electrical work is regarded as straightforward, such as domestic and smaller commercial installations, a specification is provided by the architect.

For more complex work such as commercial and multiple- occupancy buildings, hospitals and schools, the specification is developed by a professional electrical engineer.

An industry specification such as one based on a NATSPEC template will not conflict with the requirements of the Wiring Rules or any other relevant standards, but may restrict the choices that a standard allows.

For example, a specification may require all cables to have copper conductors although the Wiring Rules allow the use of cables with aluminium conductors.

Most of the specifications you will deal with in your career will be based on the NATSPEC specification system. NATSPEC is a not-for-profit organisation owned by the design, building, construction and property industry through professional associations and government property groups.

Its major service is the comprehensive national specification system endorsed by government and professional bodies.

NATSPEC provides templates covering every aspects of building, to assist architects and engineers in writing clear and concise specifications.

*www.**natspec**.com.au*

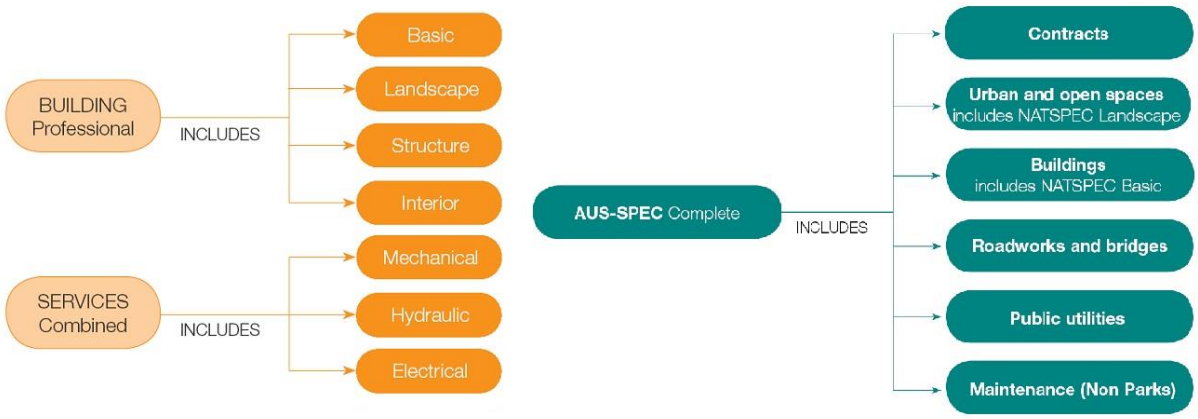
They all follow a similar format and are written in plain English without duplication or contradiction, so that contractors do not waste time clarifying project requirements.

NATSPEC is the trading name of Construction Information Systems Limited, ABN 20 117 574 606.

NATSPEC, founded in 1975, is a not-for-profit organisation that is owned by the design, build, construct and property industry through professional associations and government property groups. It is impartial and is not involved in advocacy or policy development.

NATSPEC's major service is the comprehensive national specification system endorsed by government and professional bodies. NATSPEC, the National Building Specification, is for all building structures with specialist packages for architects, interior designers, landscape architects, structural engineers, service engineers and domestic owners. AUS-SPEC is the Local Government specification system for the life-cycle management of assets. Packages include Urban and Open Space, Road works and Bridges, Public Utilities, and Maintenance. NATSPEC is also responsible for the National BIM Guide and its associated documents.

NATSPEC's objective is to improve the construction quality and productivity of the built environment through leadership of information.



Schedules

A schedule is a tabulated list of equipment with columns for each item of relevant information about the equipment and often cross-referenced to the electrical drawings or included on the drawings themselves.

Schedules are a convenient way of consolidating detailed information of the equipment involved, assisting in estimating, planning and checking work completions.

They may be incorporated in job drawings or the specification itself.

An example of the information given in various types of schedules is shown in the Figure on the next page.

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Lighting types and illumination schedule

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Cable schedule:

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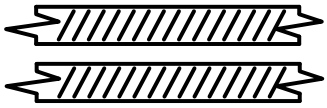
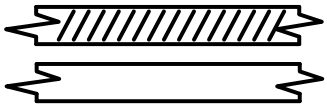
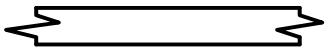
Blower	PVC circular 10 mm^2 4-core and earth	Load centre 1/4	9-A	Cable tray 1 and drop in surface-fixed steel conduit

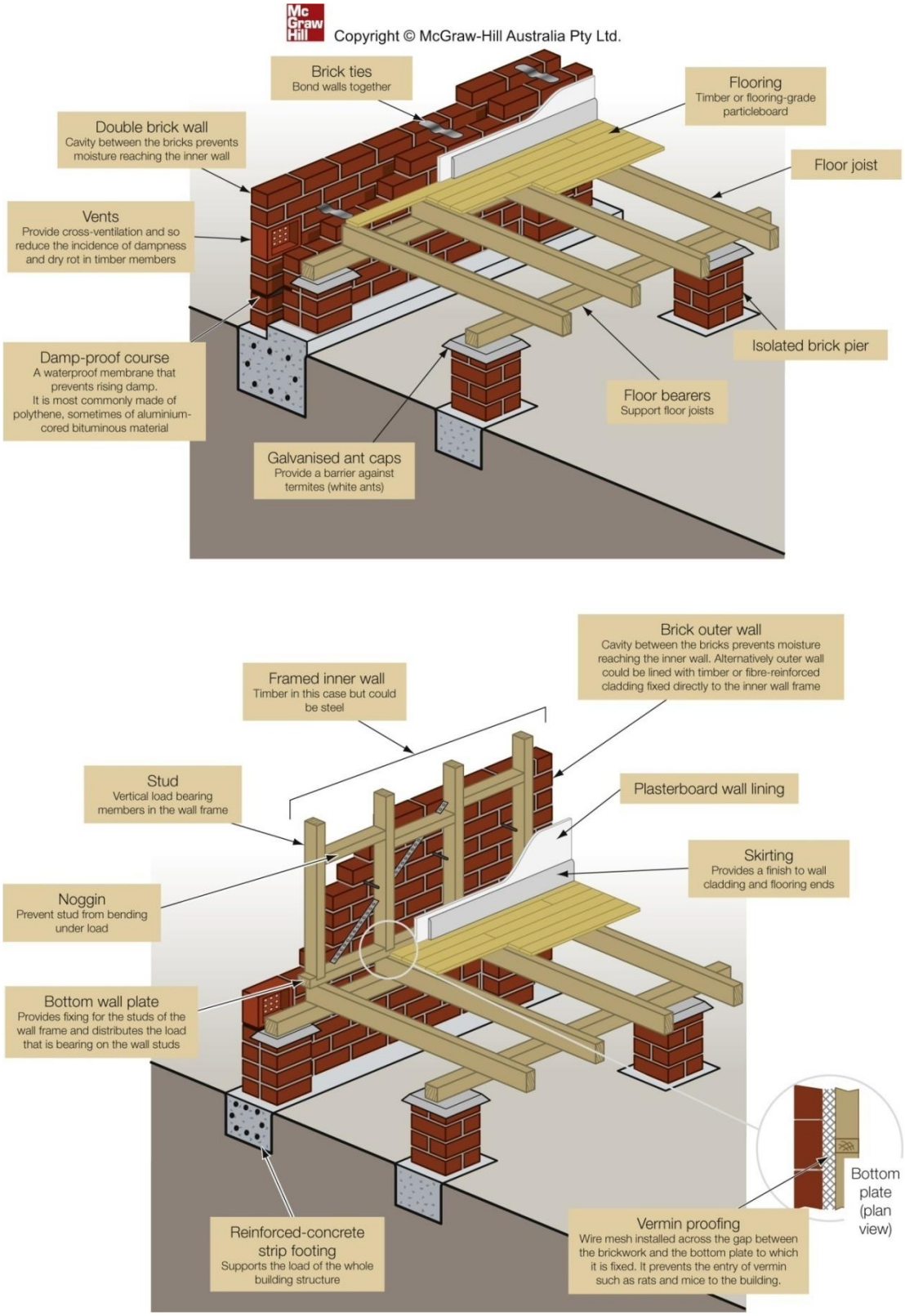
Building components and construction methods

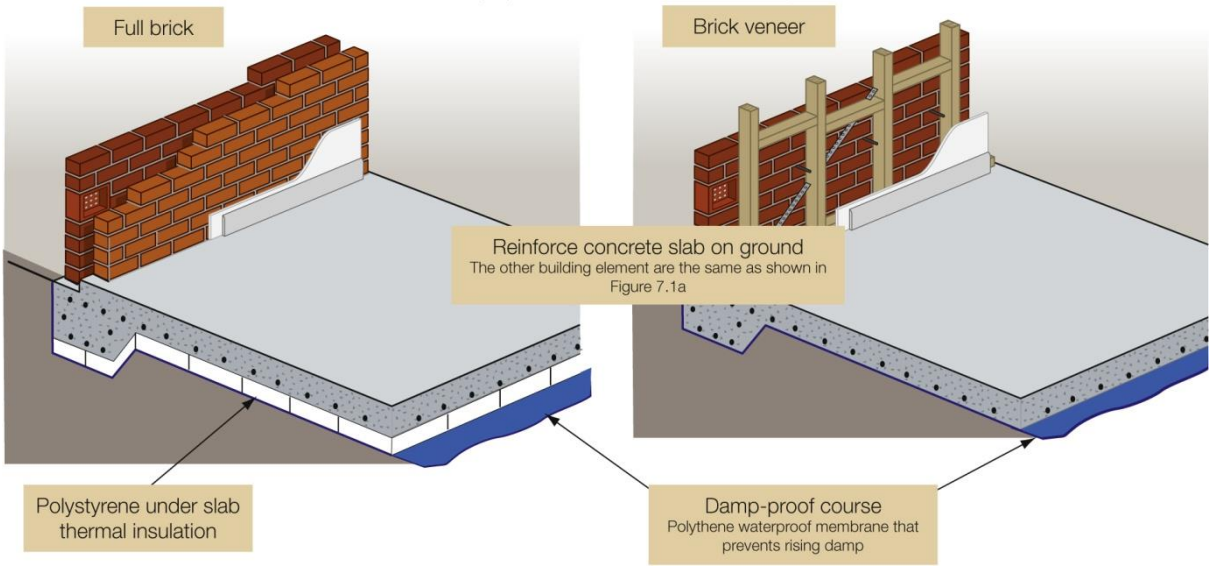
An electrician's working knowledge of construction and building methods extends to types of buildings according to intended use, types of construction defined by the structural methods and the components that affect the installation of wiring/cabling and equipment. The apprentice needs to take a particular interest in the typical routes for installing cable runs in a building, as this involves working with and around building components without damaging them. An existing building may pose an additional challenge, as the routes of cable that would normally be installed as the structure is being built are not always accessible in the completed building.

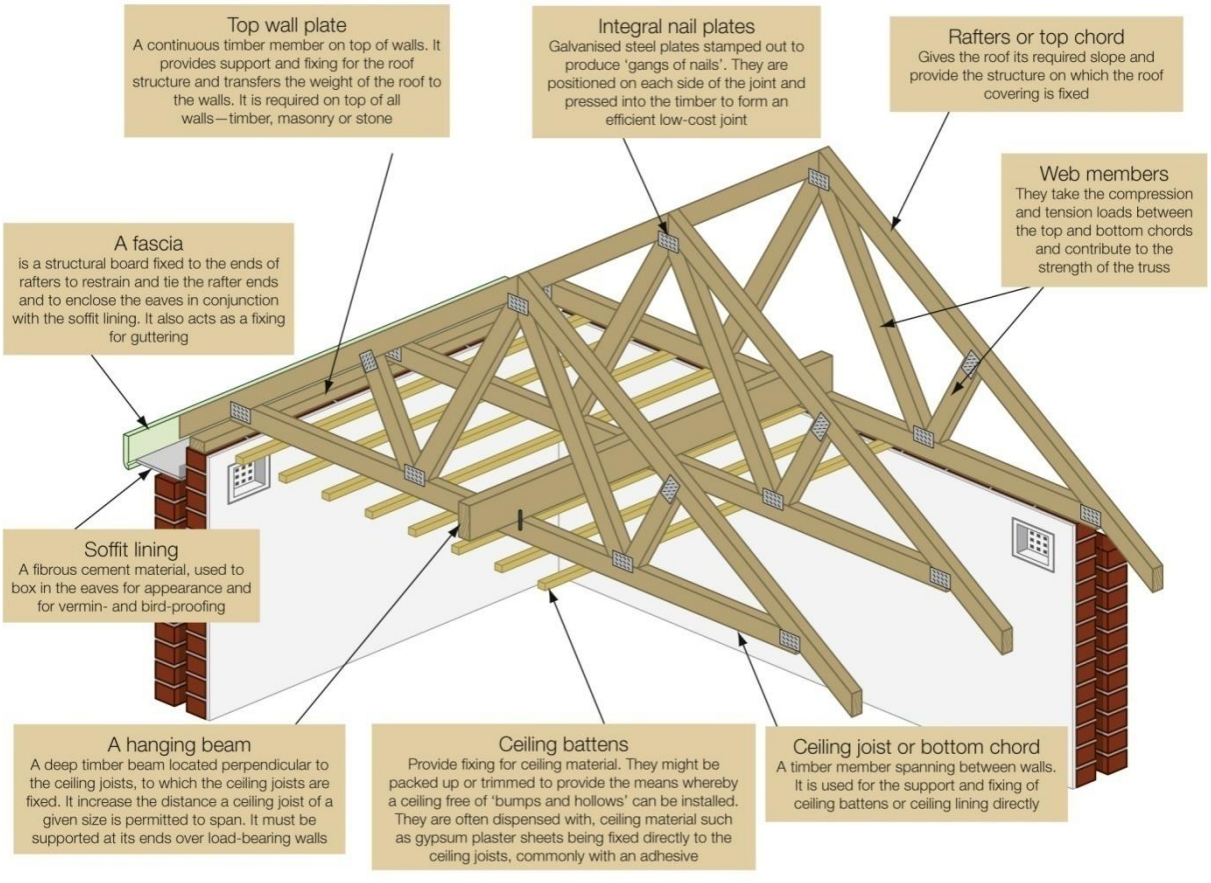
The sequence of construction is another important factor, as the electrician must be on site with the necessary materials to complete certain work as the building progresses. For example, the wiring for switches and socket- outlets needs to be installed in, say, a framed wall before the wall is lined with plasterboard. The important components for the most common building types, building sequence and cable routes are shown in the diagrams below.

Some typical components of buildings that may be seen on architectural floor plans.

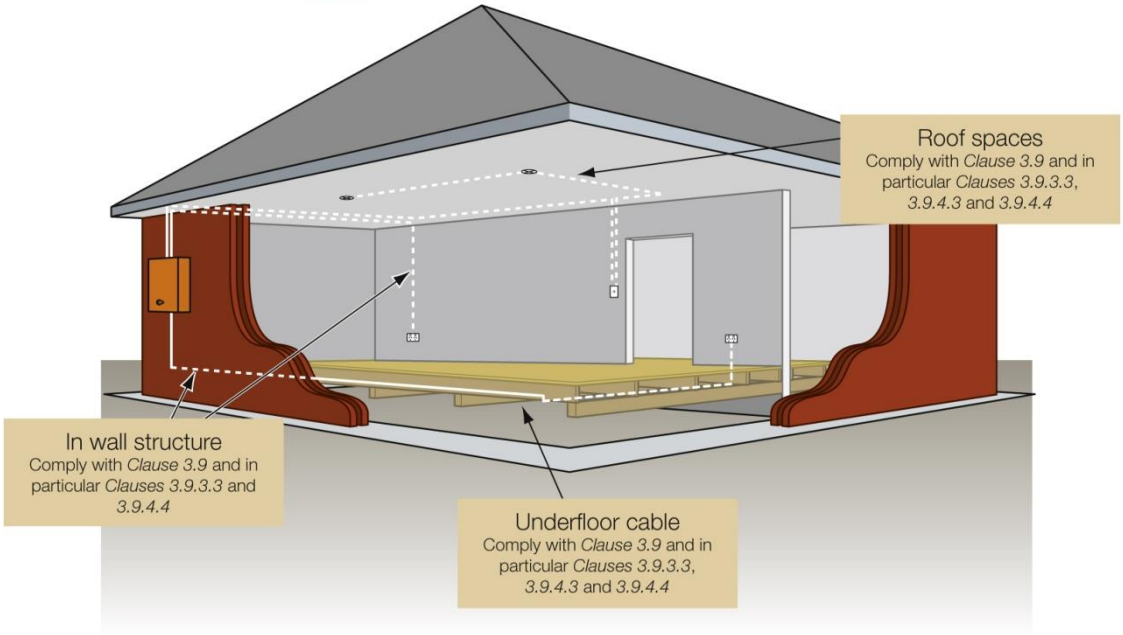
Drawing component	**Description**
	Double brick cavity wall. Hashed lines indicate a solid material ie: bricks with a gap between representing the cavity.
	Brick veneer cavity wall. Hashed lines indicate solid brick as outside wall and hollow wall internal. Stud type construction.
	Single hollow wall. Either timber or steel stud construction.
	Sliding door on outside of single hollow wall. Construction of wall can allow for door to slide into hollow section of wall.
	Double swing type doors on a single hollow wall.


Copyright © McGraw-Hill Australia Pty Ltd.
Brick ties
Bond walls together
Flooring
Timber or flooring-grade particleboard
Double brick wall
Cavity between the bricks prevents moisture reaching the inner wall
Floor joist
Vents
Provide cross-ventilation and so reduce the incidence of dampness and dry rot in timber members
Isolated brick pier
Damp-proof course
A waterproof membrane that prevents rising damp. It is most commonly made of polythene, sometimes of aluminium-cored bituminous material
Floor bearers
Support floor joists
Galvanised ant caps
Provide a barrier against termites (white ants)
Brick outer wall
Cavity between the bricks prevents moisture reaching the inner wall. Alternatively outer wall could be lined with timber or fibre-reinforced cladding fixed directly to the inner wall frame
Framed inner wall
Timber in this case but could be steel
Stud
Vertical load bearing members in the wall frame
Plasterboard wall lining
Skirting
Provides a finish to wall cladding and flooring ends
Noggin
Prevent stud from bending under load
Bottom wall plate
Provides fixing for the studs of the wall frame and distributes the load that is bearing on the wall studs
Bottom plate (plan view)
Reinforced-concrete strip footing
Supports the load of the whole building structure
Vermin proofing
Wire mesh installed across the gap between the brickwork and the bottom plate to which it is fixed. It prevents the entry of vermin such as rats and mice to the building.





Note. The top and bottom chords and web members make a typical grefabricated timber roof truss



Constructional Sequence

The usual sequence of stages of construction of the house can be seen in the following listing (Figure 6)

Some variations may occur due to the type of construction, or to local factors.

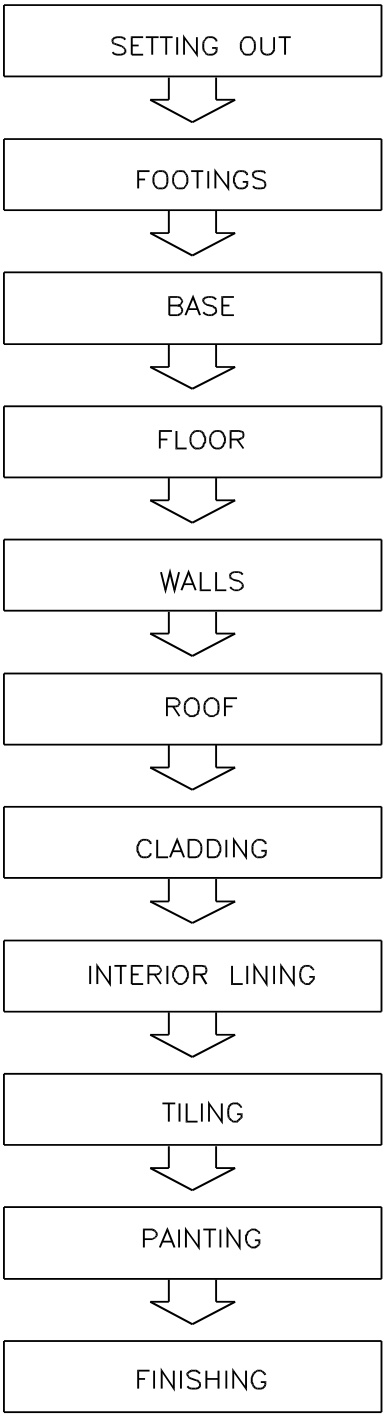
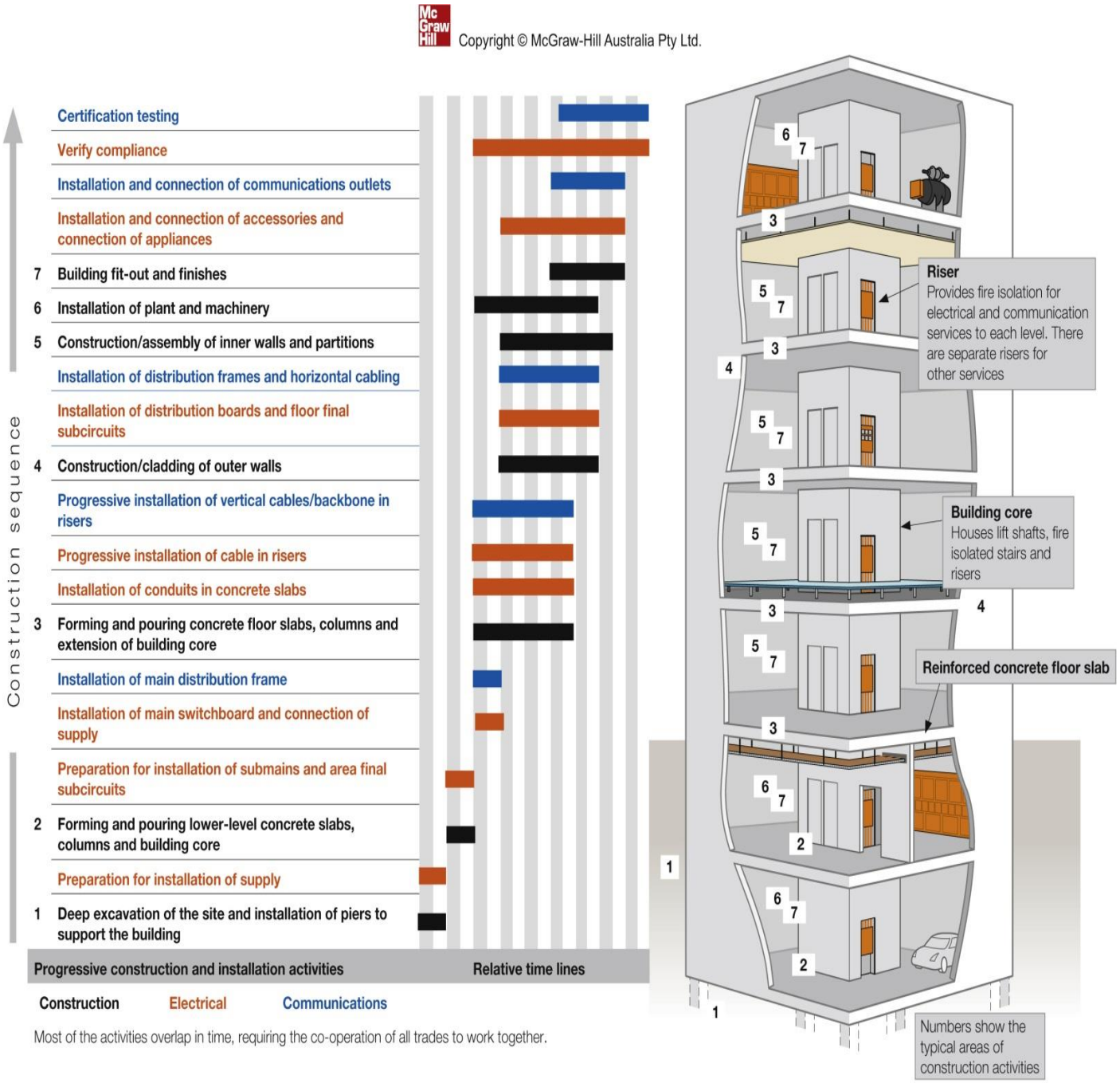


Fig 6 SEQUENCE OF CONSTRUCTION STAGES

Example Sequence of Construction



Electrical Trade Requirements

The electrician needs to be aware of the different stages in order to organise his work for minimum interference for himself, and the other trades.

Figure 7 indicates those points of the construction sequence where the electrician must perform certain tasks.

The two main stages are often referred to as ‘roughing in’ or ‘first fixing’ and ‘fitting out’ or ‘second fixing’.

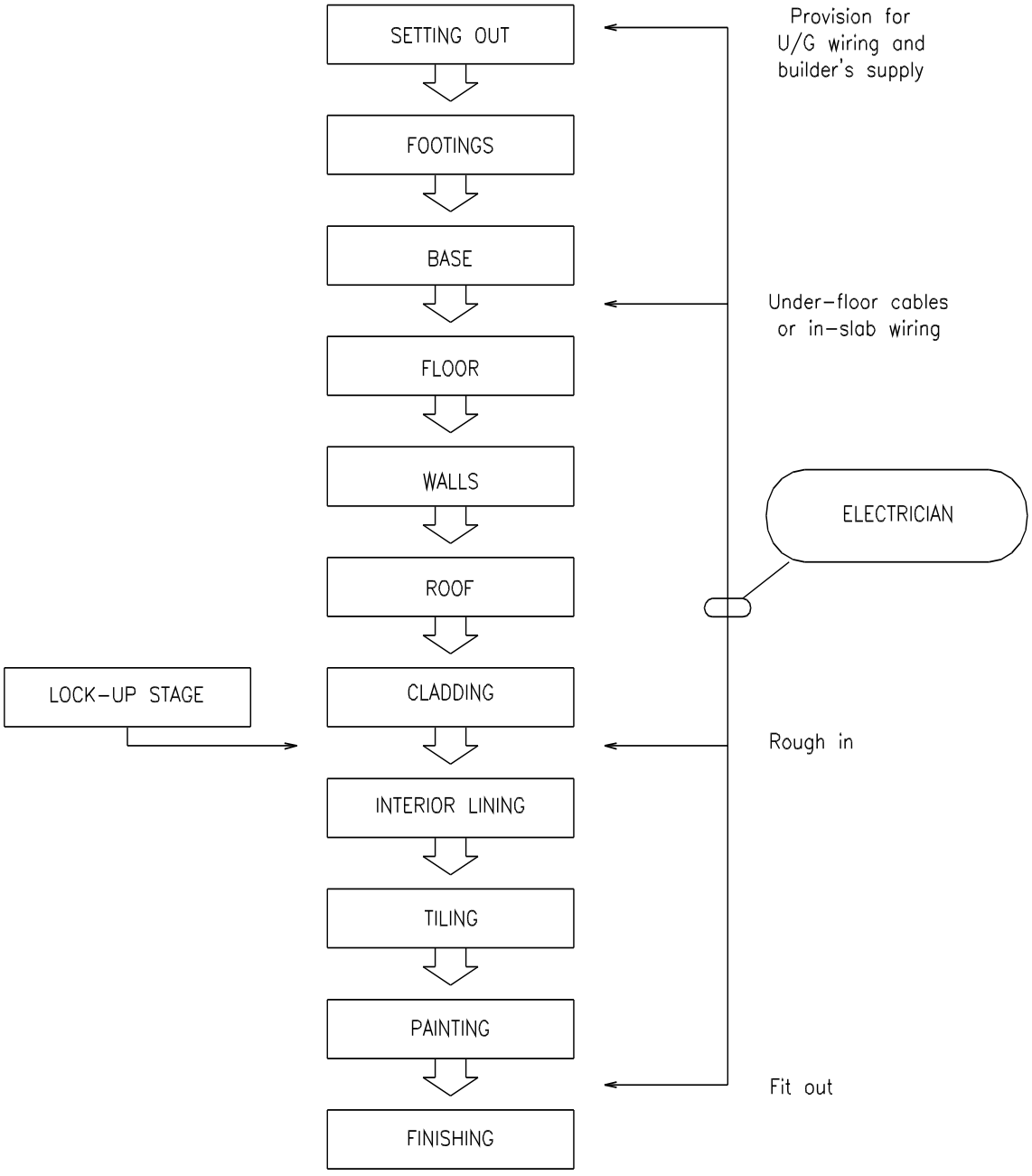


Fig 7 ELECTRICAL TRADE INVOLVEMENT

Inter-trade Relationships

The electrician may have to co-ordinate his efforts with any or all of the other trades involved in the cottage construction.

Figure 8 illustrates the general sequence and relevant involvement of other trades.

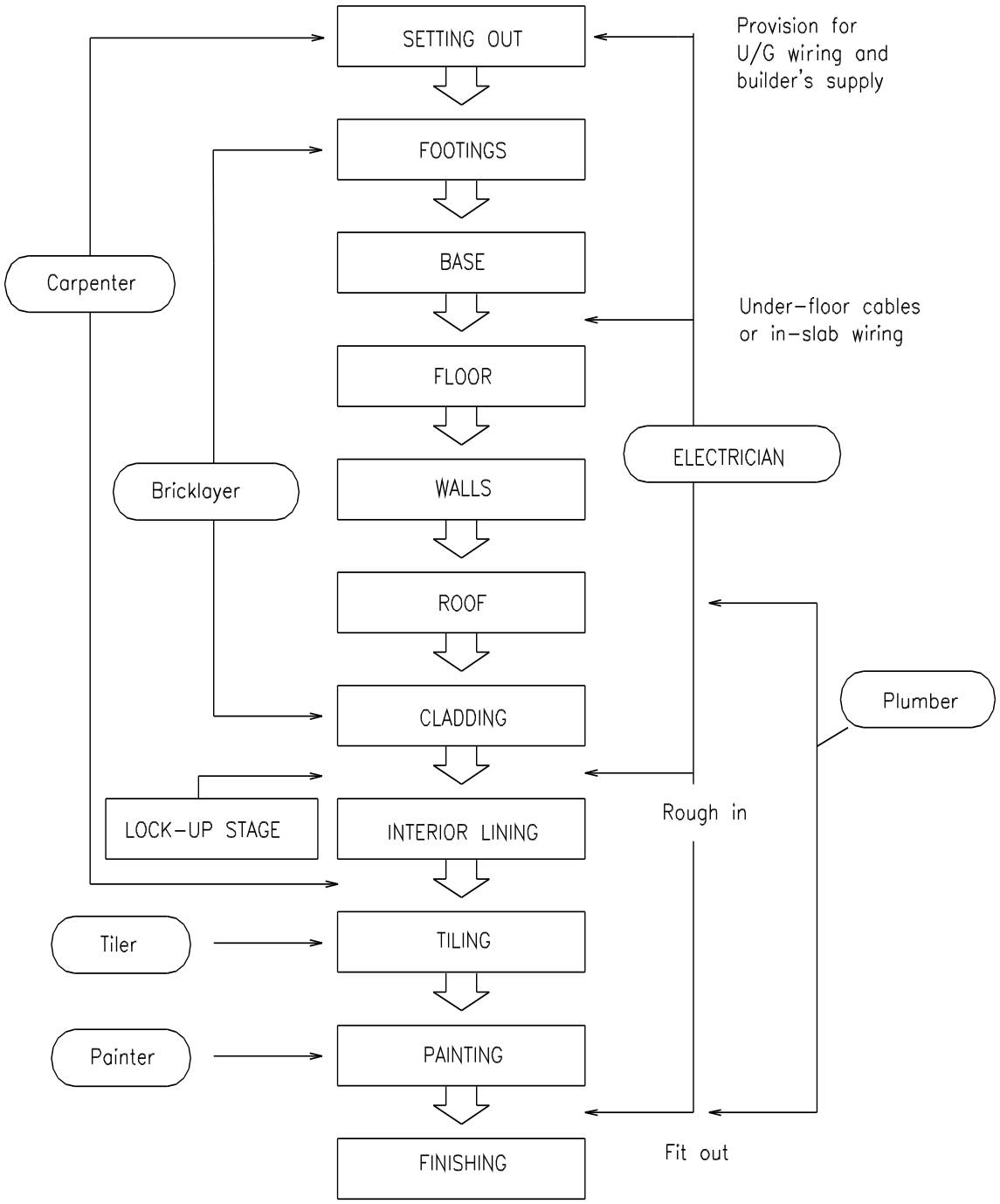


Fig 8 INTERTRADE RELATIONSHIPS

Topic 5 Worksheet 5-1

1. Draw a basic circuit, labelling all the components.

2. What is the purpose of a switch in a circuit?

3. In a practical circuit, why is the voltage drop in the circuit conductors kept to a minimum?

4. Describe the features and the purpose of a circuit diagram and a wiring diagram.

5. Explain the conventions of series and parallel circuits.

6. What are the main uses of wiring diagrams?

7. How are circuit diagrams used?

8. Explain why is an ‘earth wire’ is required at a stop; forward; reverse station?

9. What is the purpose of a grid system on circuit diagrams?

10. With aid of a sketch, describe the conventions for a symbol used to represent a fuse switch.

11. What is the importance of equipment supplier/ manufacturers’ installation instructions?

12. What is the purpose of a contract between an electrical contractor and a client?

13. List the types of items covered in a contract.

14. What is the purpose of a specification?

15. How are specifications used?

16. Describe the format of a typical specification.

17. What information is included in the work sections of a typical specification?

18. Why are schedules used in a specification?

19. List the types of information given in a typical lighting schedule for an installation.

20. Describe the item represented by the following location symbols:

21. A builder has given you a drawing and basic specifications on page 93, which is for a one-bedroom unit that is to be completely renovated.

On the drawing, show the locations of the following items using standard location symbols:

(a) Switches and the points they control

(b) socket-outlets

(c) Telephone and communication outlets

(d) TV outlets.

Tip: Think about the most likely and convenient locations for these items.

22. Compile a materials list for the installation in question 21.

Domestic Construction Building Methods

23. List two types of material used for constructing the internal wall frames of a domestic building.

24. List three different methods used for house construction.

25. In relation to the installation of wiring, describe the meaning of the following terms.
    a. first fixing (rough in)
    b. second fixing (fit out)

26. Explain the difference between load bearing and non-load bearing walls.

27. When installing wiring in the cavity of a cavity brick wall, explain why it is important that the cables don't touch both the internal and the external walls.

28. Name three materials commonly used to clad the internal walls of a house.

29. List four materials used to clad the external walls of a house built using timber frame construction.

30. The column below, lists the constructional stages of a timber framed cottage.

    Number the stages in the correct sequence of construction.

    Base
    Cladding
    Finishing
    Floor
    Footings
    Interior lining
    Painting
    Roof
    Setting out
    Tiling
    Walls

31. Sketch a sample of a sliding door as would be seen on a typical architectural drawing.

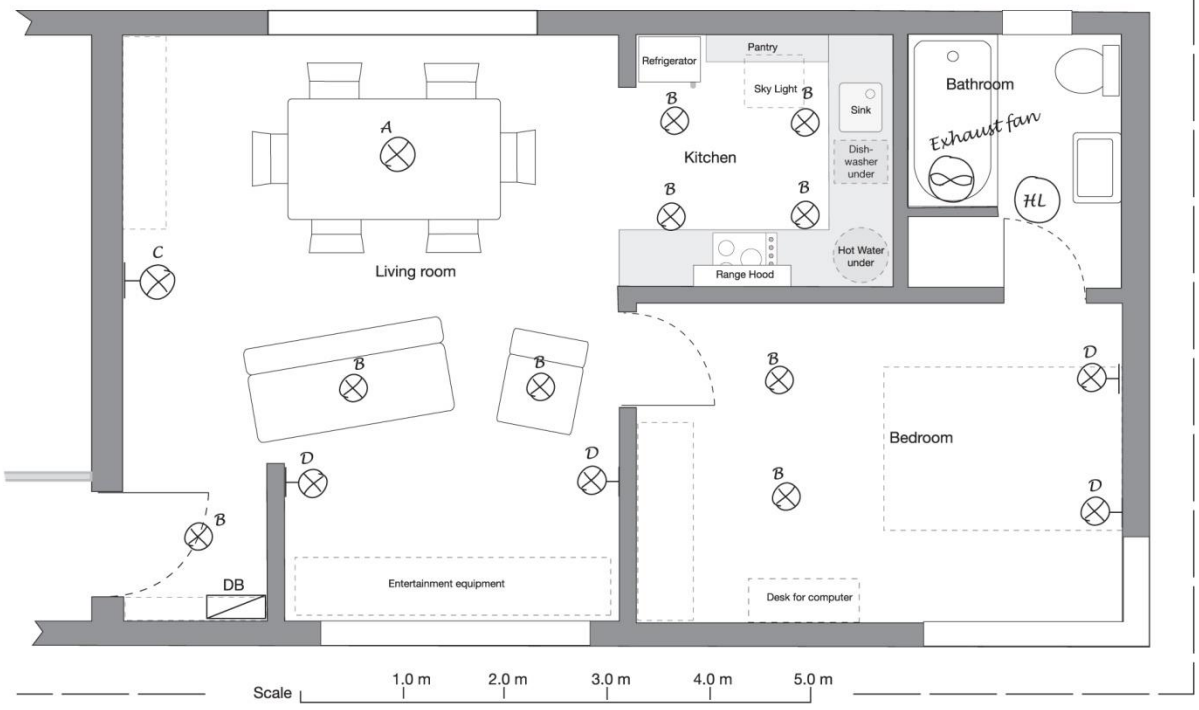
32. Sketch a sample of a double brick wall as would be seen on a typical architectural drawing.

33. Sketch a sample of a stud wall as would be seen on a typical architectural drawing.

34. Sketch a sample of a pair of double doors as would be seen on a typical architectural drawing.

35. Using the table below state where you would carry out your pre lay, 1st fit or "rough in" and second fit or "fit off". Consider when you would be carrying out your fit off. What other trades would you need to liaise with in order to ensure an efficient and harmonious workplace is maintained?

Description
Setting out
Footings
Base
Floor
Walls
Roof
Cladding
Interior lining
Tiling
Painting
Finishing



Specification

The site

The unit is on the top floor of a two storey unit block. The construction is full brick with a pitched tile roof and tiled concrete floors. There is access to the ceiling space above the unit. Ceiling height in the unit is 2.7 m.

Circuits

Half the number of light points and socket-outlets are to be distributed across each of two 16 A circuits.

Notes:

1. Socket-outlets are required for the refrigerator, dishwasher and range hood.
2. Check *Clause 6.2.4* for restrictions on socket-outlets, accessories and luminaires in bathrooms and near water containers.

The range is rated at 10 kW and is to be protected by 25 A circuit breaker.

Note: Check *Clause 4.7.1* for requirement for switching devices for cooking appliances.

The continuous water heater is rated at 3.6 kW and is to be protected by a 16 A circuit breaker.

Cables

The submains are to be 16 mm^2 2 core and earth TPS. Route length to the main switchboard is 9.0 m.

Use *Table C6* in *Appendix C* of the *Wiring Rules* to select cables.

Notes:

1. Cable sizes are given in Column 1 of the table.
2. Protection device ratings are given in Column 3 as the most onerous conditions for this installation are 'In thermal insulation partly surrounded'.

Lighting schedule

A	Three lamp pendant	Supplied by owner
B	Recessed compact fluorescent down light	Supplied by electrical contractor
C	Wall mounted halogen up light	Supplied by owner
D	Wall mounted compact fluorescent	Supplied by electrical contractor
HL	Heat lamp	Supplied by electrical contractor

Introduction to Regulations, Technical Standards, codes of Practice and Specifications

Introduction

Arrangements for generating, distributing and supplying electricity to consumers in the competitive energy market is governed in Australia by the Australian Energy Market Act 2004 which covers marketing of all forms of energy to ensure efficiency and safety of supply and fair pricing for consumers.

Under this legislation development and administration of national electricity regulations and rules are the responsibility of the Australian Energy Market Commission (AEMC), a body representing all jurisdictions (state and territory governments).

Penalties may be imposed on generation, transmission and distribution entities that do not adhere to the regulations and rules. Similar arrangements apply in New Zealand.

In addition to this, each jurisdiction has legislation and regulations related to electrical safety and consumer protection that include requirements for licensing persons to carry out electrical work and undertake electrical work as a contractor.

In order to meet your legal responsibilities as a licensed electrician or contractor you must have a sound knowledge of the regulations and rules that govern the administration and technical requirements for electrical systems and installations in buildings and premises.

More importantly, you must be able to apply the regulations and rules.

This includes specific regulations of the state authority and Australian or New Zealand Standards called up by legislation, in particular, the principal technical legal requirement, which is published under the title Australian/New Zealand Standard Electrical installations and known as the Australian/New Zealand Wiring Rules AS/NZS 3000:2007.

For our purposes, this important publication will be referred to as the Wiring Rules and reference to it and other related standards will be shown in italics.

The first step is to learn the format of the Wiring Rules.

This, together with a detailed study of the definitions (Clause 1.4) used in the Standard, will give you the basic vocabulary of electrical terms necessary to access information.

Through a study of Part 1, you will gain an understanding of essential safety requirements and the electrical installation process and standards with which your work must comply.

As you progress in your training, you will develop the ability to apply the Wiring Rules to each work situation.

Electrical licensing

The purpose of the licensing laws and regulations in Australia and New Zealand is to ensure the personal safety of members of the public and electricity users by protecting them from death or injury by electrocution, and to reduce the possibility of property damage.

To ensure this, the law requires that electrical work be carried out by licensed persons in a competent manner befitting a trained electrician.

The licensed electrician must carry out their work in strict accordance with the Wiring Rules and any relevant codes or requirements of statutory authorities, the service and installation rules of energy distributors and any additional specification that may apply to particular jobs.

The term ‘electrician’s licence’ is a generic one, referring to an authorised document that states a person is eligible to do particular electrical work.

For example, in New South Wales the licence is titled ‘qualified supervisor certificate— electrical’, while in South Australia it is called ‘registered electrical worker’ and in Victoria it is known as an electrician’s licence.

The meaning of the term electrical work is an important one when discussing the legal requirement that such work shall be done by a licensed person.

Although electrical work may be described in different ways across the various jurisdictions it can be defined as installing, testing, maintaining and servicing low-voltage electrical equipment in buildings and premises.

Relevant legislations that apply to WA are the Electricity Act 1945 and the Electricity (Licencing) Regulations 1991.

Information on obtaining and using a licence is shown on the next page.

About Licensing

Types of licences issued by all jurisdictions

Electrician's licence
- permits the holder to carry out electrical work unsupervised
- permits the holder to supervise such work
- does not permit such work to be done for commercial gain.

Electrical contractor licence
- permits the holder to undertake electrical work for commercial gain
- can be held by an individual, partnership or company
- work must be carried out or supervised by the holder of an electrician's licence.

Restricted electrical work licence
- issued to particular non-electrical tradespersons to carry out restricted electrical work that is incidental to their normal duties. For example, mechanical maintenance have the need from time to time to disconnect a motor in order to carry out mechanical repairs on plant or machinery
- generally restricted to disconnecting and reconnecting equipment
- categorised by the types of equipment permitted. Some jurisdictions issue licences for electrical fitting work and electrical service work.

Electrical apprentices
In some jurisdictions electrical apprentices are issued with a permit, while in others their status to carry out electrical work under supervision is determined by local training regulations.

How to qualify for a licence

The Electrical Regulatory Authorities Council (ERAC) represents all states, territories and New Zealand on matters of technical electrical regulation. For uniformity of electrical licensing across all jurisdictions ERAC developed 66 essential capabilities that must be demonstrated through:
- training package qualification
- recognition of current competencies
- a combination of both.

Restricted electrical work licences are only issued for certain categories of work, and to qualify a person must:
- possess trade-level skills in a specified category
- demonstrate a need for the licence
- undergo a prescribed competency based training program.

Responsibilities of licence holders

Electrical licences are issued on behalf of the community to persons who have shown they are competent to do the work for which the licence is issued. With this comes the responsibility to uphold the standards expected; there is no excuse for such a licensed person to act incompetently. These responsibilities are listed below.

Holders of an electrician's licence must:
- comply with the requirements of the *Wiring Rules*, local distributors' service rules and any other statutory requirement such as in a local or national building code
- verify their completed work complies with the Standards
- complete and issue certificate of compliance for work for which they are the licence holder
- supervise the work of trainees/apprentices.

Holders of an electrical contractor licence must:
- accept the responsibilities of the licensed electrician where they are carrying out the work themselves
- engage licensed electricians to carry out the work of an electrician
- keep all records required by statutory regulations.

Holders of a restricted electrical work licence must:
- work strictly within the scope permitted by the licence
- ensure electrical circuits/equipment worked on are safe to use
- notify of the need for a licensed electrician for work beyond the scope of restricted electrical work.

Who issues licences?

Electrical licences are issued by the following authority in your jurisdiction:

ACT	Planning and Land Authority
NSW	Department of Fair Trading
NT	Electrical Workers and Contractors Licensing Board
QLD	Department of Employment and Industrial Relations
SA	Office of Consumer and Business Affairs
TAS	Workplace Standards Tasmania
VIC	Energy Safe Victoria
WA	Energy Safety WA

Most of these authorities do more than issue electrical licences and their structure and name may change from time to time. A national licencing scheme is under development.

Licence holders are obliged by these laws to show their licence if requested to do so by a representative of an energy distributor, licensing authority, a member of the police force or the owner or occupier of the property on which the work is being carried out.

A licence may be suspended or cancelled for any one of a number of reasons, which include making an unauthorised connection, tampering with meters or other property of an energy distributor, or carrying out work not in accordance with the Wiring Rules or within the scope permitted by the licence.

In Western Australia The Electricity (Licencing) Regulations 1991 deals with the Licencing Board, Licencing of workers/ contractors, regulation of Electrical Work and Electrical workers.

Standards

The purpose of standards is to set minimum safety and performance requirements for the design of products and provision of services without stifling innovation or placing artificial barriers on trade between enterprises, states or countries.

Many of the requirements described in a standard are set to ensure that a product or service is safe and reliable.

Most Australian standards are developed and published by Standards Australia, a non-profit organisation recognised by Australian governments as the peak standards body in Australia.

Through Australian and New Zealand economic ties, Standards Australia has a formal agreement with Standards New Zealand to develop joint standards. Standards are developed through various Standards committees made up of experts and representatives of organisations with a particular interest in a Standard. Standards are published under a title that indicates their purpose and a number that includes the year of publication. Standards are under continual review and updated periodically.

There is a trend towards internationalising standards as part of a strategy to remove anything that might be a seen as a barrier to fair trade between countries.

Standards Australia, as a member of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC), is a major contributor and ensures that the views of Australian industry are represented to the global community.

Standards are often called up by a statutory regulation, and when this occurs they in fact become part of the regulation and must be complied with.

Electrical workers must perform their work to comply with many standards, in particular the Wiring Rules.

This Standard in turn calls up other related standards or is referred to in other standards. So an essential part of electrical work, is knowing how to use the Wiring Rules.

In addition, the electrical worker must also meet the requirements of the local regulatory authority Western Australian Electrical Requirements (WAER)

Brief history and background of the Wiring Rules

Due to a lack of stringent government controls, installations in the early days of the electrical industry were primitive and often dangerous.

Due to the number of fires attributed to the new agent of electricity, fire insurance companies quickly realised the need for regulations to govern the installation of electrical wiring, and each insurance company initially had its own inspectors and rules.

The situation in Australia in those early days can only be described as chaotic; the various states sometimes had widely differing rules.

How the change came about from no uniformity of regulations to the national standard we have today is summarised in the table below.

1908	The rules of the English Institution of Electrical Engineers were, with addenda, adopted by the Fire Underwriters' Association of NSW, VIC, QLD, SA and TAS.
1918	These rules were amended and additions were made to suit Australian conditions by a conference of electrical inspectors representing the Fire Underwriters' Association of NSW, VIC, QLD, SA, TAS and WA and issued under the title *General Wiring Rules*.
1921	Further revisions of the *General Wiring Rules* were made.
1923	The Australian Institute of Engineers issued a publication *Electrical Wiring Rules*, which was based on the previous code and was the outcome of conferences held in Melbourne and Sydney.
1929	The state and federal governments sponsored the establishment of the Standards Association of Australia, now known as Standards Australia, for the promotion of standardisation and simplified practice.
1931	The *Australian standard rules covering the essential requirements and minimum standards electrical installations for buildings, structures and premises*, also known as the *SAA Wiring Rules, Safety Code No. CC1—1931*, was published.
1934 to 1991	The *Standard* underwent nine revisions, the 1991 edition was titled *Electrical installations—Buildings, structures and premises*, known as the *SAA Wiring Rules*.
1990s	A new approach to the *Wiring Rules* was developed. This was influenced by new trade agreements and international trends to emphasise performance-based requirements for the safety of installations rather than to prescribe safety through restrictive practices. Also at this time Standards Australia and Standards New Zealand agreed to publish joint standards.
1997	The first joint Australian/New Zealand *Standard* was published, titled AS/NZS 3018:1997 *Electrical installation—Domestic installations*. This is a **deemed-to-comply** standard, that is, an installation carried out to this standard will comply with the *Wiring Rules*.
2000	The tenth edition of the *Standard* was published as AS/NZS 3000:2000 *Electrical installation*, better known as the *Australian/New Zealand Wiring Rules*. This edition is based on the performance for safety approach developed in the previous decade.
2007	The eleventh edition of the *Standard* AS/NZS 3000:2007 *Wiring Rules* was published. Experience with the adoption of the tenth edition (AS/NZS 3000:2000) has led to the inclusion in this latest edition of more guidance on the reasons for particular rules and how they may be applied. Amendments to this edition were published in 2009.

Wiring Rules development

The Wiring Rules are developed by the Wiring Rules Committee (designated EL-001) in which all sections of the electrical industry are represented as listed at the front of the Wiring Rules.

Committee EL-001 also oversees the work of a number of sub-committees which develop other standards that support the Wiring Rules such as AS/NZS 3017: 2007 Electrical installations—Verification guidelines.

The development process is managed by a Standards Australia project manager.

It is a fundamental policy of Standards Australia that suggestions or criticisms can be made by any person or organisation.

Such suggestions or criticisms are influenced by many factors, such as the interpretation of particular rules, the development of new technologies and materials, changes in government policies, health and safety and environment concerns, trends in international standards and simply by new ways of doing things.

These matters are reviewed by the EL-001 Committee and may result in the publication of amendments to the current edition of the Wiring Rules.

When sufficient changes warrant the need for a new edition the EL-001 Committee applies to the Standards Council for approval to produce one. Several months prior to the publication of a new edition of the Wiring Rules.

Standards Australia issues a draft publication to invite comments from any interested group or individual.

Feedback of comments is reviewed by the EL-001 Committee and changes to the draft standard are made where agreed.

The whole process is based on agreement between all members of the committee, who vote on the final draft before publication.

In this way the Wiring Rules reflect the standards expected of the whole electrical industry and the community as closely as possible.

The current Wiring Rules are the accepted Australian and New Zealand rules and are incorporated in the regulations in each jurisdiction; they are the minimum legal requirements and their provisions are enforceable by law.

Standards Australia provides a commercial service to answer questions in respect to specific rules or the use of methods or materials. Some enquiries may be directed to the EL-001 Committee for resolution.

Matters that contain specific requirements and require immediate application might result in amendments to the Wiring Rules.

Purchase of the amendments is necessary for electricians to keep their copy of the Wiring Rules up to date.

The 2000 edition of the Wiring Rules stipulated the requirements to which an installation must conform in terms of safety and functionality and follows many aspects of the international standard IEC Publication 60 364.

The performance approach to specifying standards allows for much more innovation in installation design.

At the same time this requires a complete understanding of electrical principles and how they are applied, particularly in respect to providing protection and safety in electrical installations.

This edition was criticised for the absence of information that was in previous editions that helped in applying the Standard.

As a result the 2018 edition includes with the fundamental safety performance principles of the Standard.

Those charged with the design and installation of electrical wiring and equipment must be thoroughly familiar with the use and application of the Wiring Rules to ensure the safety and effectiveness of the electrical system in a building or premises.

A competent electrician regards the Wiring Rules as a tool and keeps up to date with any changes, amendments and revised editions. You should realise how important it is to acquire the ability to think and work within the limits of the current edition of the Wiring Rules.

The wiring rules, in setting out the safety and functional requirements to which a completed electrical installation must conform, contains numerous tables or references to other standards, sample calculations, and notes to permit, for example, the correct cable, rating, type and enclosure to be chosen for a particular application.

It should be remembered that the Rules are minimum requirements and that, where necessary, the additional rules of any regulatory authority or energy distributor must be observed.

Typically, the electrician will be mainly concerned with the additional service and installation rules of the local energy distributor.

When commencing a job in an unfamiliar district, the first step is to obtain a copy of the service and installation rules for the supply of electricity in that district.

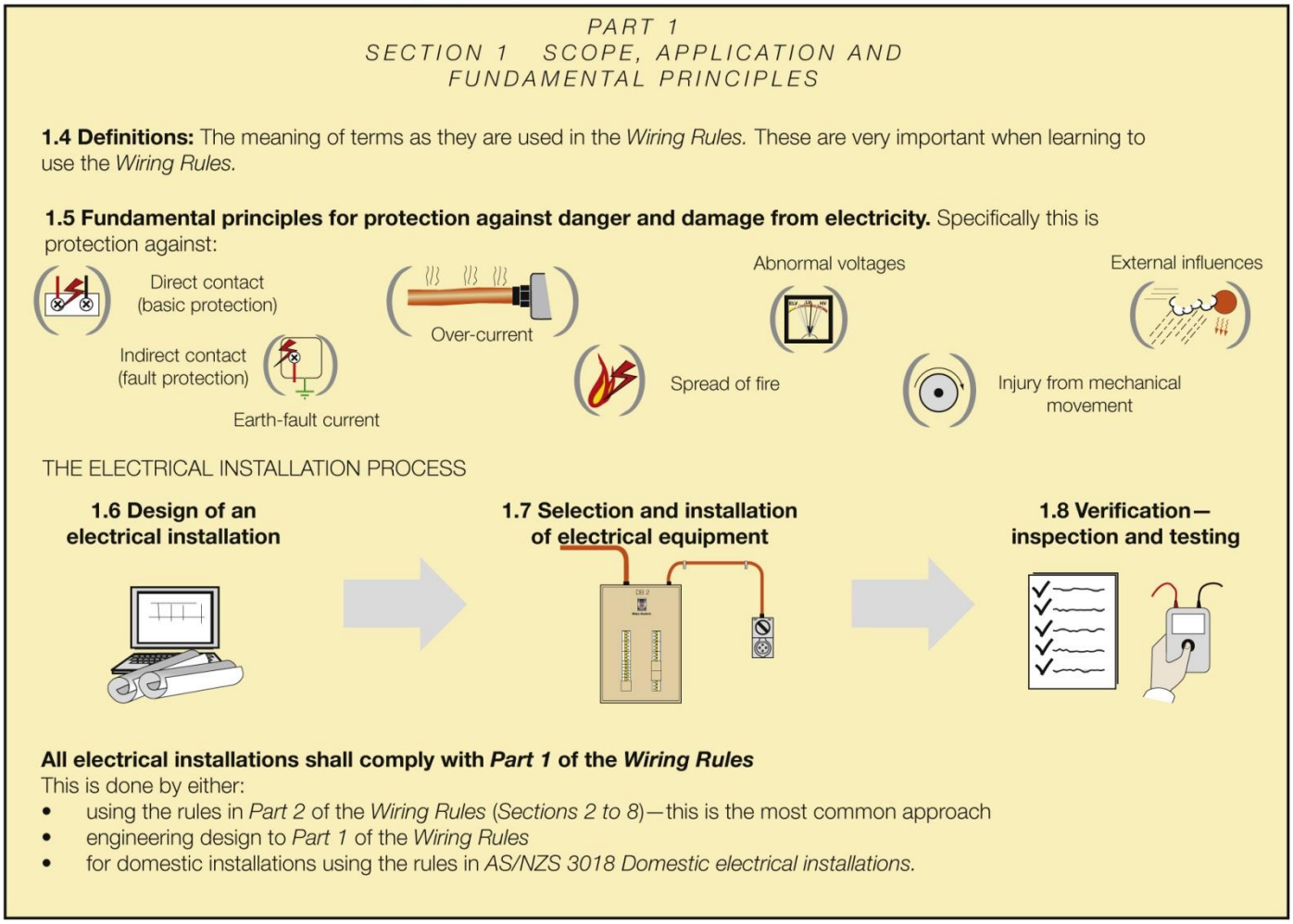
These should be studied in conjunction with the Wiring Rules.

An electrical installation must also comply with contractual arrangements, usually contained within a job specification.

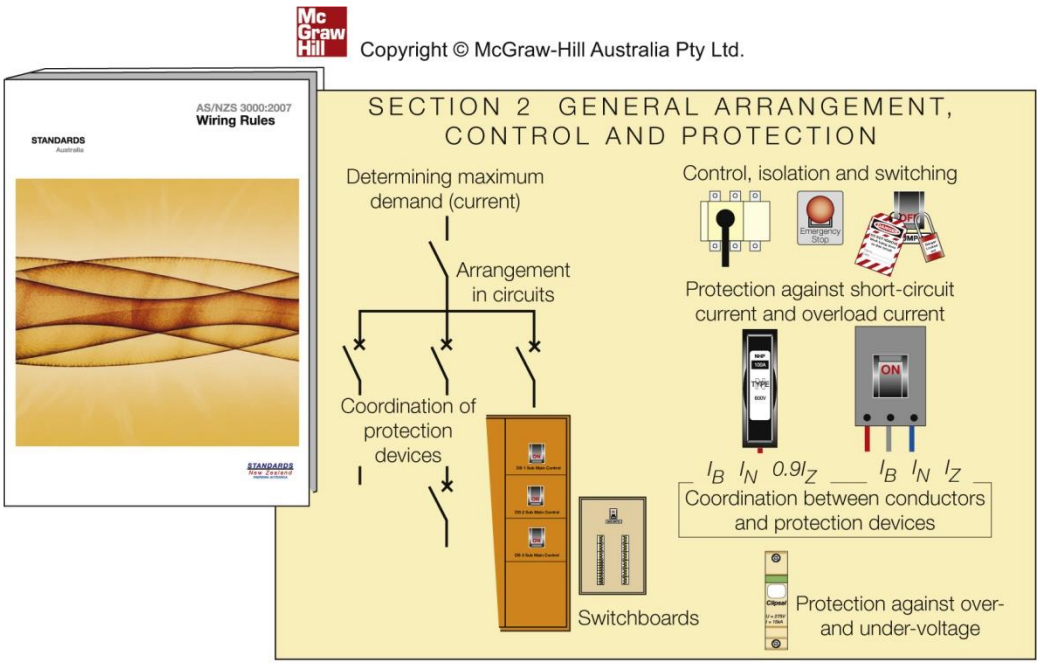
Wiring Rule set up

The Wiring Rules is set out in two parts and eight sections.

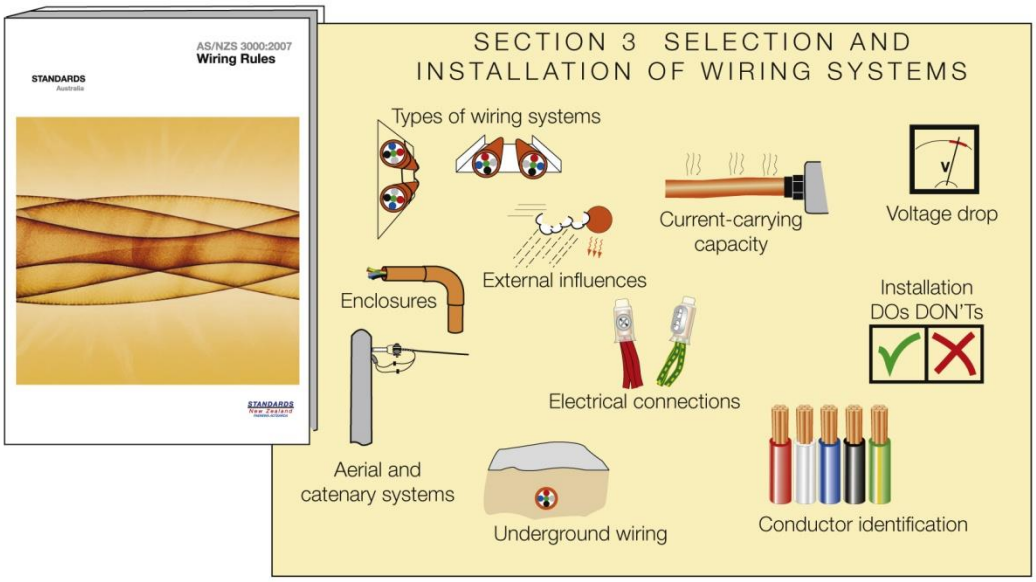
Referring to the diagram below, Part 1 sets the safety and performance standards to which an electrical installation shall comply.



Part 2 provides installation practices that achieve certainty of compliance with the standards set out in Part 1.



Rules dealing with selecting and installing switchgear and controlgear commencing with supply requirements, circuit arrangements and control of the installation. This is followed by devices and arrangement for fault protection, protection against overcurrent, indirect contact and unde and ovevoltage. The section also covers rules for switchboards.



Rules for selecting and installing cables, cable supports systems and protection methods. This covers the acceptable wiring systems, the current a cable can carry without overheating, permitted voltage drop, electrical connections and how the function of cables are to be identified. It includes everyday rules for installing cables and rules specific to wiring enclosures, underground and overhead wiring and busway systems.

Note that the book follows a logical plan, with rules commencing at the supply end of the installation through to requirements for the selection and installation of wiring, equipment and earthing.

These are followed by requirements for special types of installations and then verification by inspection and testing.

It finishes with appendices for information and guidance in applying the requirements of the Standard. Tackling the Wiring Rules may seem difficult at first but by viewing it as a series of eight separate books (the eight sections) with the Appendices as the help file, the task of using it will become much easier.

How the Rules are written

The Rules are written in the form of clauses designated by a point numbering system, the first number identifies the section under which the clause appears. Try the following exercise.

Exercise 3.1

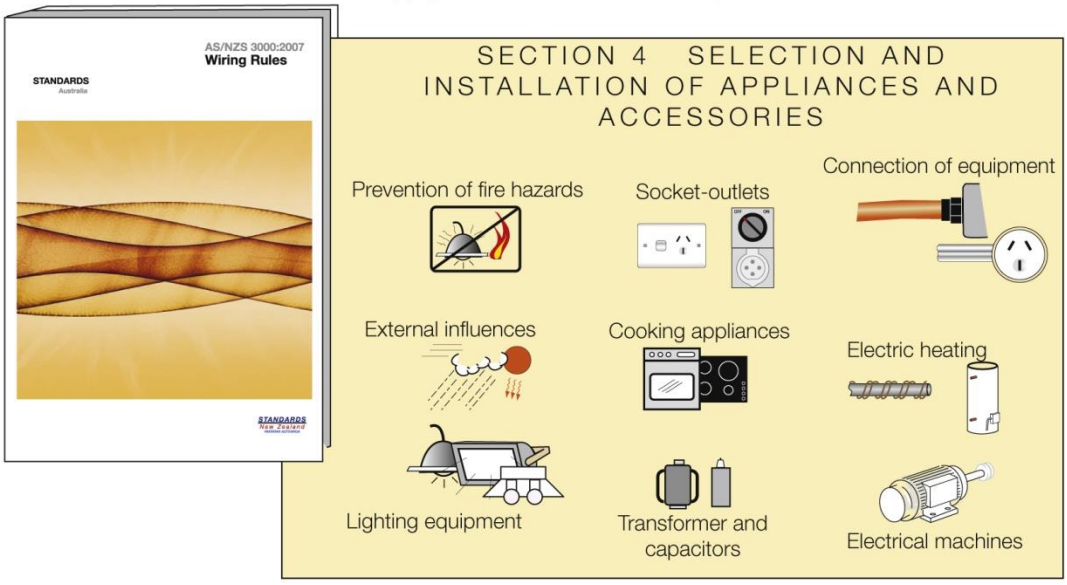
Open the Wiring Rules at Section 4 Selection and installation of appliance and accessories.

Note that all the clauses start with the number of the section, in this case 4, and main requirements for each aspect of Selection and installation of appliances and accessories are listed under clauses numbered 4.1, 4.2, 4.3 and so on.

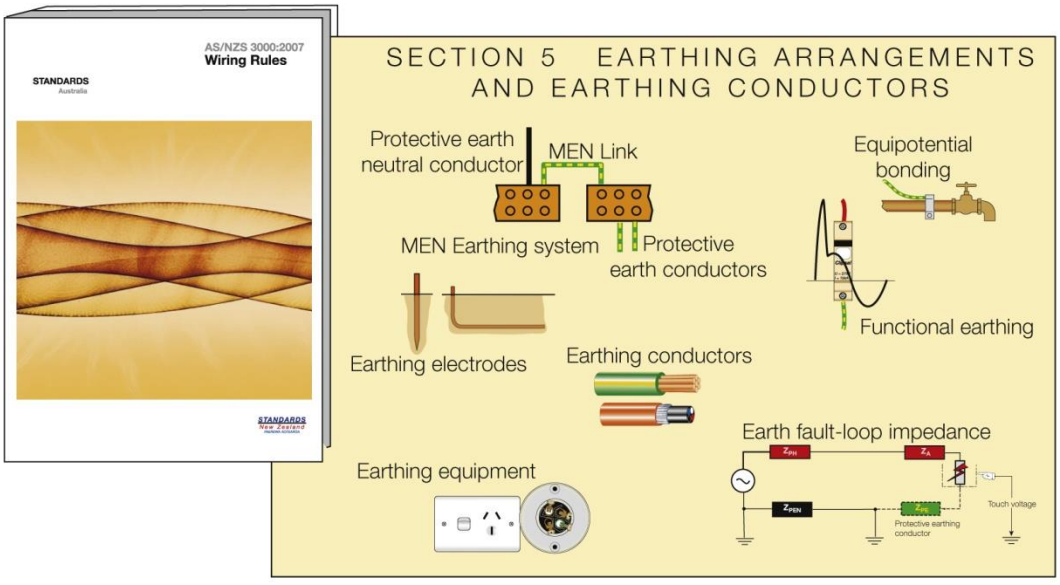
Now look up Clause 4.4 Socket-outlets.

As the information about socket-outlets becomes more specific, that part of the clause is given a new heading and an additional point and number.

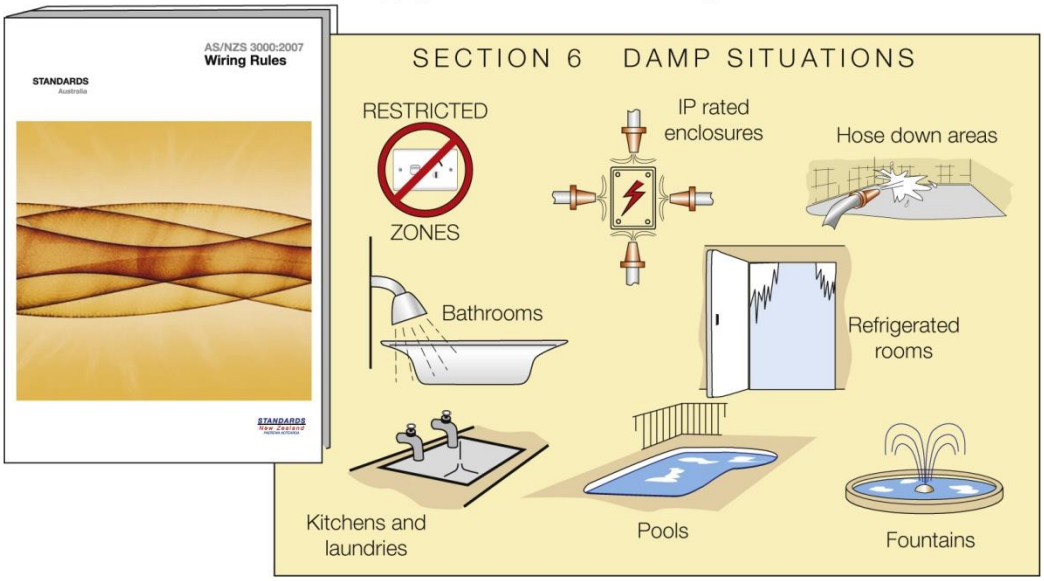
In this case Clause 4.4.1 covers Types (of socket-outlets), while under the heading types the more specific requirement for suitability, the clause General is given number Clause 4.4.1.1. Clauses like 4.4.1 and 4.4.1.1 are often called subclauses.



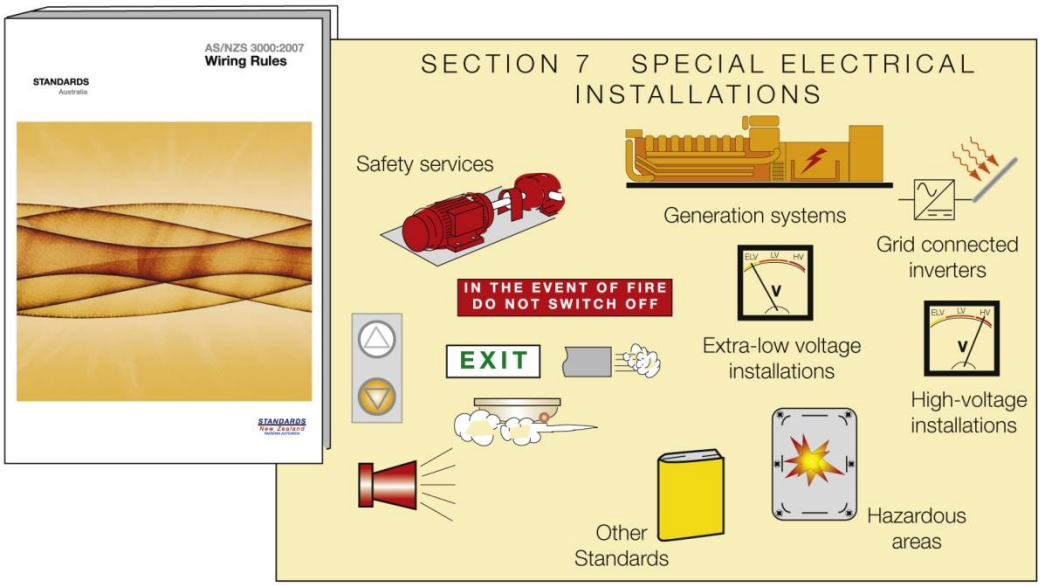
Rules about protecting property and persons from the heat generated by electrical equipment and acceptable methods of connecting electrical equipment. Also covered are rules particular to socket-outlets, lighting, smoke and fire detectors, cooking appliances, applications of electric heating and control, electrical machines, transformers, capacitors and batteries.



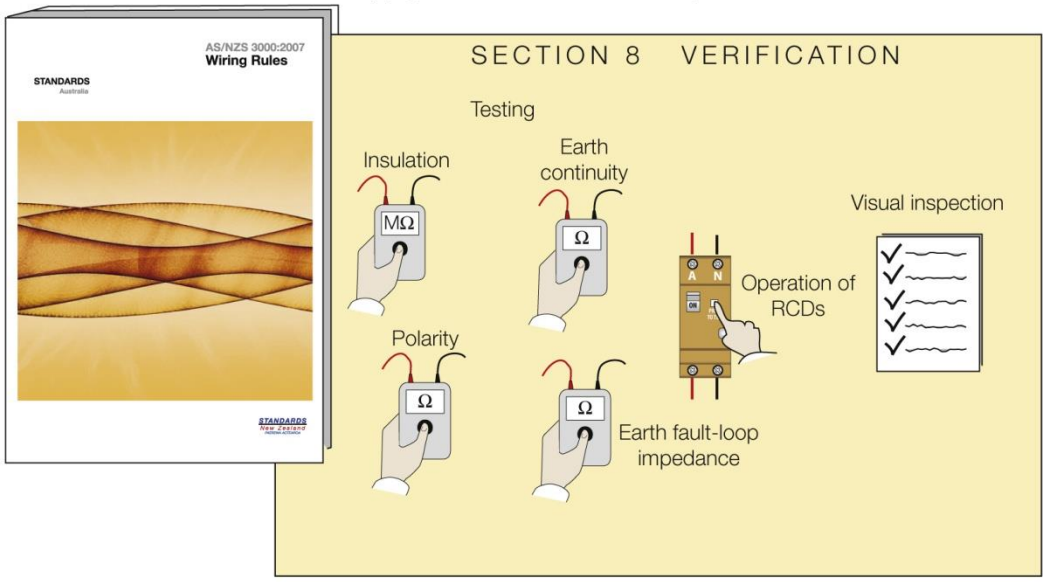
Important from the safety point of view, this section covers rules for acceptable arrangement of earthing in an installation, selecting earthing conductor sizes, selecting and installing earth electrodes, equipotential bonding and earth fault-loop impedance.



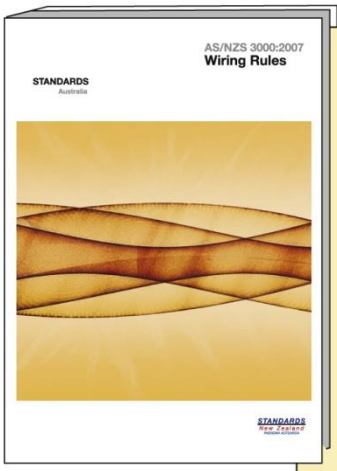
Rules dealing with parts of an electrical installation in areas that are wet or damp at sometime in their normal use. This covers restriction on installation of electrical equipment in designated areas (zones) in bathrooms, kitchens, laundries, saunas and around pools and fountains. Also, there are rules that apply to installations in refrigerated rooms and areas that are regularly hosed down, e.g. meat processing areas, greenhouses and livestock areas.



Rules for installing the electrical systems for the safety services in a building, i.e. fire and smoke detection and control and building evacuation services. Rules included are those for installing generator sets, stand-alone power systems, battery systems, grid connected inverters, isolated supplies and extra-low voltage systems. The section refers readers to *Appendix K* for rules on high-voltage installations, and the standards for installations in hazardous areas. Finally specific installation standards and deemed-to-comply standards are listed.



The final activity of an electrician before handing over the the user is to verify that it complies with all safety requirements, that is, it complies with the *Wiring Rules*. The verification rules cover the visual inspection of the accessible parts of the installation and tests to be carried out. Tests include insulation resistance, earth continuity, polarity of all circuits, particularly that of mains and submains, earth-fault impedance and operation of RCDs.



APPENDICES

- **A** Referenced Documents
- **B** Circuit Protection Guide—Theoretical background
- **C** Circuit Arrangements—Effecting factors; maximum demand calclations; simplified cable selection tables; guide to number of cables in conduits
- **D** Minimum Sizes of Posts, Poles and Struts for Aerial Line Conductors—Selection factors; examples and tables
- **E** Electrical Installation Requirements in National Building Codes—General information
- **F** Installation of Surge Protective Devices—Selection, location and connection.
- **G** Degrees of Protection of Enclosed Equipment—International Protection (IP) ratings
- **H** WS Classification of Wiring Systems—Characteristics of the degrees of protection
- **I** Protective Device Ratings and Metric Equivalent Sizes for Imperial Cables used in Alterations Additions and repairs—Relevant to old installations
- **J** Symbols Used in this Standard
- **K** High Voltage Electrical Installations—Interum information pending the publication of a separate standard
- **L** Electric Shock Survival—Australia
- **M** Electric Shock Survival—New Zealand

Purpose of different typefaces used in the Wiring Rules

Fundamental principle	**Bold type—an opening statement which sets out the basic principles and purposes of the requirements that follow**
Mandatory requirements	Normal type—the mandatory requirements which specify methods that may be employed to comply with the Rules.
Exceptions	*Italics—exceptions and/or variations to the mandatory requirements.*
Explanatory notes	Reduced type—notes that give further explanation or advice on the application of a clause.

In addition to this arrangement of clause numbering, the information in clauses (and subclauses) is presented in a ranked order, each having a different typeface as described in Table 3.2. (above).

Appendices

The 2018 edition of the Wiring Rules makes more use of the Appendices than the previous edition to provide information to help you apply the Rules.

Appendices are primarily for guidance and give information and examples for application of the Rules and some theoretical background to the purpose of various requirements. As such, most are designated informative.

The exception is Appendix K High voltage installations, which is designated normative, meaning that it specifies the mandatory requirement for high-voltage installations. A standard for high-voltage installation is under development.

To differentiate from the requirements given in clauses, the information in the appendices is given in numbered paragraphs identified by the letter of the appendix in which they appear.

A numbering system similar to that used for the clauses then follows.

Using the Wiring Rules

An electrician on varied worksites will often need to refer to a copy of the Wiring Rules.

The more varied the work, the more often it will be necessary to refer to a specific Rule for information on a particular installation.

The Wiring Rules are a tool—as essential as a pair of pliers or a testing device—and for them to be useful, the time required to locate and interpret a Rule must be kept to a minimum.

To achieve this, the student must firstly understand the organisation, or overall plan of the book, and secondly be familiar with the terms and language used.

Section 3.5 of chapter 3 deals with this aspect.

When using the Wiring Rules, electricians need to:

- locate specific information.
- apply the information to a particular situation.

To become adept at use of the text, practice in both these areas is necessary.

The two methods for locating specific information in the Wiring Rules use:

- the table of contents at the beginning of the book.
- the index at the end of the book.

Using the table of contents

It is recommended that you start by using the table of contents to locate information, because this will help you to gain an understanding of the layout of the book and knowledge of where particular types of information are likely to be located.

It will also help in developing a vocabulary of wiring language.

Locating information using the index becomes more effective once this knowledge has been acquired.

Try this exercise.

Exercise 3.2

To answer an enquiry about the requirements of locating a switchboard in a cupboard in a single domestic dwelling (i.e. a house or individual home unit) try the following procedure:

1. From the Contents, select the section that is likely to contain the information required.
   Because Section 1 deals with protection for safety and overall requirements, the required information is not likely to be under these headings.
   Likewise, for Sections 3, 5, 6, 7, because these cover Selection and installation of wiring systems, Earthing, Testing and special types of installation.
   This leaves Sections 2 and 4 to consult.

2. Read the clauses listed under the selected sections in the contents and locate a clause that appears to deal with the location of switchboards. Under Section 2, Clause 2.10 Switchboards is listed.

3. Turning to Clause 2.10, read the headings of subclauses listed under this main clause until a clause covering the required information is found. In this example, Clause 2.10.2 Location of switchboards and its subclause seem to be specific to the enquiry.

4. Be sure to read the chosen clauses thoroughly, including all related notes, tables and cross-references. In this case, the required information is provided by Clause 2.10.2.5, which restricts the location of a switchboard, and by part (a) of the clause, which prohibits the installation of a switchboard within 1.2 m of the ground, floor or platform. However, part (c) of the clause allows a switchboard to be installed in a cupboard essentially dedicated for the purpose. This information can now be applied when installing the switchboard.

Using the index

Once experience has been gained in this manner, using the index method becomes more appropriate. Index listings have been arranged under key words.

Try this exercise.

Exercise 3.3

Index listings are arranged under key words. For a query regarding the location of a switchboard, the likely key word is ‘switchboards’.

1 Check the **index** of the Wiring Rules for ‘switchboards’ as a heading.

2 Beneath this, look for the subheading ‘location’.

3 Look up the references given, Clauses 2.10.2 and 2.10.2.3, and see that neither refers specifically to switchboards located in a cupboard.

4 Return to the Index and under the ‘switchboards’ heading look for another subheading containing the word ‘location’; here you find ‘restricted locations’ listed with reference to Clause 2.10.2.5 and others starting with ‘6’.

These can be ignored as they are in Section 6 Damp (situations which is not relevant to our inquiry).

5 As with the previous exercise Clause 2.10.2.5 is found to provide the information on the conditions for installing a switchboard in a cupboard. Alternatively, if ‘location’ is taken as the key word, no listing can be found in the index.

It is therefore important to determine the likely key word in an enquiry when using the index.

This exercise demonstrates the need to develop a vocabulary of wiring language and the arrangements and numerous components that make up an electrical installation.

How the references are used

A clause might refer you to an appendix, or to other Standards for further information or to determine specifics for a particular application.

Try this exercise.

Exercise 3.4

You are selecting a cable for a particular circuit and need to know the smallest permitted conductor size that can be used.

The conductor size of a cable is determined by its current-carrying capacity.

1 Open the Wiring Rules at Section 3 and turn to

Clause 3.4 (Current-carrying capacity)

2 Read Clause 3.4.1 General which refers to compliance with the AS/NZS 3008.1 series of cable selection Standards.

3 Go to Note 1 of the clause to find that Appendix C.

Paragraph C.3 provides a set of current ratings for common simple circuits that comply with AS/NZS 3008.1.

This example of cross-referencing to other Standards is typical throughout the Wiring Rules and demonstrates how the appendices are used to help apply the Rules

Note. Installations in Western Australia **MUST** comply with WAER. (Western Australian Electrical requirements) in conjunction with Building Code of Australia.

These requirements take precedence over AS/NZ 3000-2018.

KS02-EE107A – Worksheet 1
Regulations, Technical Standards, codes of Practice and Specifications

1. Refer to the AS/NZS 3000:2018, state the clause number that relates to the installation work practice relating to installation of equipment to manufacturer's instructions. State the clause number.

2. What is the purpose of technical standards, according to the AS/NZS 3000?

3. Name the Joint Technical Committee that has input into the development of the AS/NZS 3000:2018 standards?

4. What organisations of the Committee EL-001, are responsible for the inclusion of adherence to standards in the structure of legislation, as listed in the AS/NZS 3000:2018? List FIVE of these organisations.

5. Name the local Energy Safety publication that determines the regulations for electrical installations in W.A?

6. According to AS/NZS 3000:2018 what is the requirement with regard to switching in pendant outlets? State the clause number?

7. Which authority in W.A is responsible for the application of the W.A Electrical Requirements and what is the date reference on the current version in use?

8. What is the purpose of electrical licensing regulations?

9. What requirements must the work of an electrician comply with?

10. What scope of work is permitted under a restricted electrical licence?

11. What type of licence is required to undertake electrical work for profit?

12. Outline the regulation that permits an electrical apprentice to undertake electrical installations.

13. Who is responsible for ensuring that a new electrical installation is safe and complies with the *Wiring Rules*?

14. Who is eligible to receive an electrician’s licence?

15. Describe the purpose of a Standard?

16. How are Standards enforced?

17. Outline the process by which Standards are developed.

18. How can you have a say about a Standard?

19. What aspect of electrical installation does each section of the *Wiring Rules* cover?

20. What is the difference between *Part 1* and *Part 2* of the *Wiring Rules*?

21. By what means may complex requirements of an electrical installation be met?

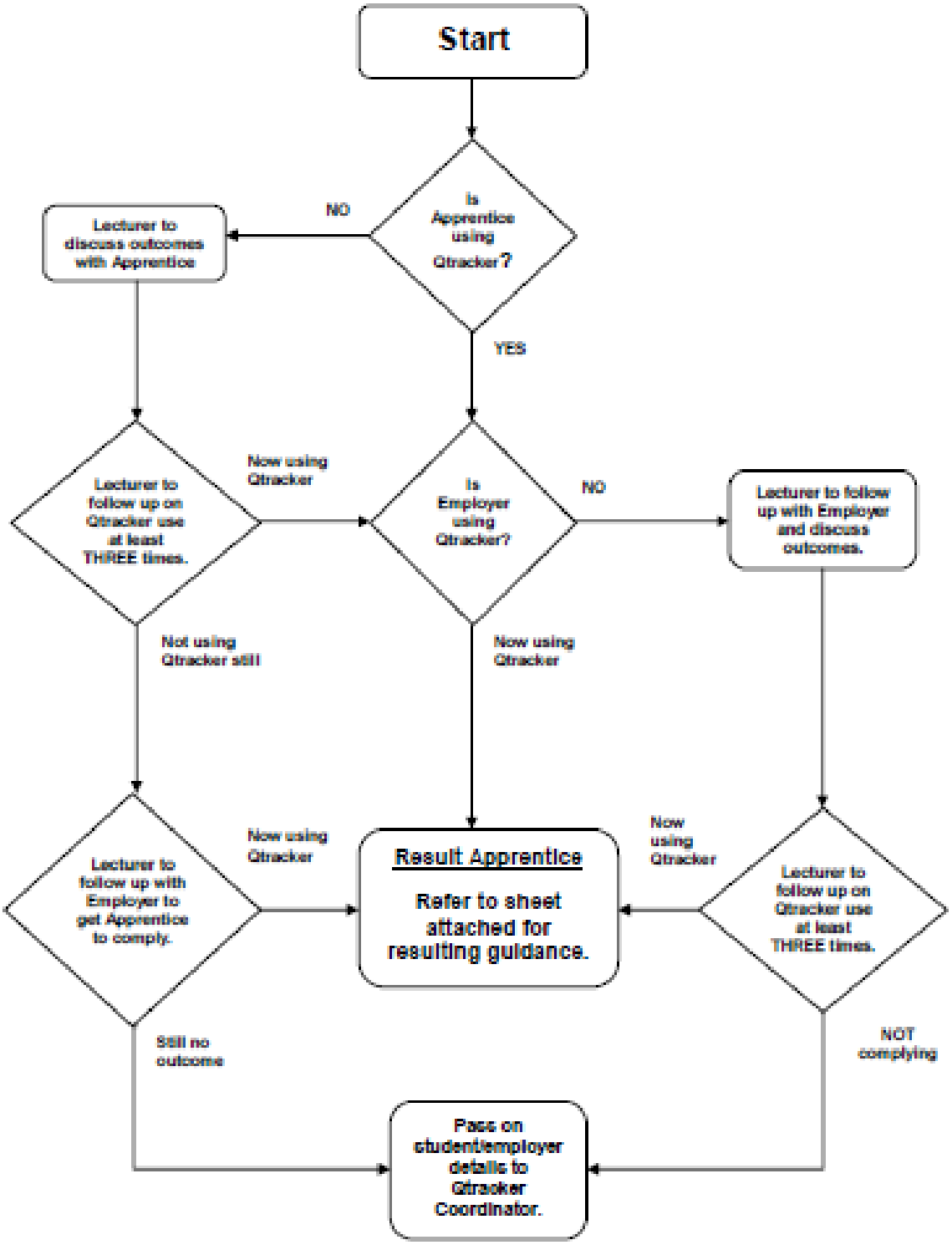
22. Explain the form in which Rules are written in the *Wiring Rules* and how they are structured.

23. What is the purpose of the different typefaces used in the *Wiring Rules*?

24. What is the purpose of the *Wiring Rules Appendices* and how are they structured?

25. Explain what is meant when an *Appendix* is designated as informative or normative?

Work flow Qtracker Responsibilities



Resulting Guideline for Qtracker outcomes

First year resulting:

- All stage 1A and 1B units of competency will be resulted as CO on passing the unit at TAFE, irrespective of Qtracker hours logged.
- Student overall Qtracker hours should be approximately 25% at the end of stage 1B.

Second year resulting:

- All stage 2A and 2B units should be resulted as CO on completion of TAFE studies and have accumulated approximately 50% of their Qtracker hours logged for the unit of competency completed.
- Approximately 50% means roughly 40 – 60% and you will be required to use your discretion as a trained assessor.

Third year resulting:

- All stage 3A units should be resulted as CO on completion of TAFE studies and have accumulated approximately 75% of their Qtracker hours logged for the unit of competency completed.
- Approximately 75% means roughly 65 – 85% and you will be required to use your discretion as a trained assessor.
- **NOTE** - The 3B elective Telecommunications unit (F002) is an elective and it is not imperative that they reach a high percentage of hours in Qtracker for this unit.

Final resulting of C020:

- C020 is to be resulted on completion of all the OTJ (Off the Job) training at TAFE and 100% recorded (hours) in Qtracker.
- 100% recorded (hours) in Qtracker, means 100% in all units and not 100% on the overall averaging bar at the top of the Bar Graphs.
- Our main focus is on the "G" units (Installing), the students must reach 100% or more.
- Students are required to continue to update Qtracker, even once 100% has been achieved. This would look better if the units where 200, 300 or 400%, especially if Energy Safety request a report.

NOTE: It is imperative that staff make sure that students understand what is required of them when inputting into Qtracker and the relevance between their daily activities to the units of competencies. Students are also required to enter the hours they attend TAFE, which may cover all hours required for some units of competencies.