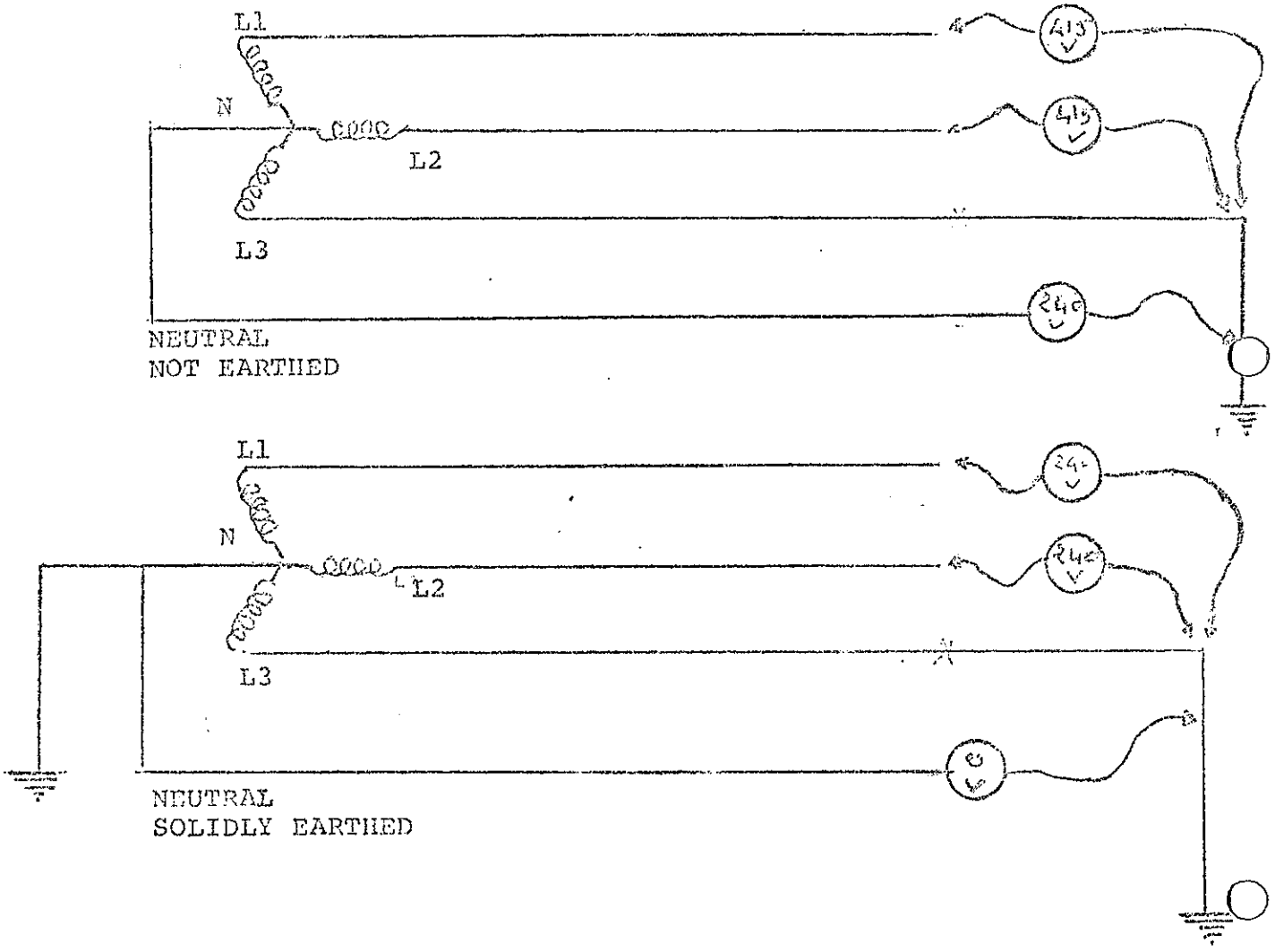
Solidly Earthed

Term used to describe the usual system of earthing where the neutral at the source of supply is connected direct to the earth electrode.




The term "Solidly Earthed" applies to the supply system. It should not be confused with the term "Direct Earthed", also known as Direct Earthing System, which refers to the system of earthing at the consumer's installation.

Earth Bond

This is the connection between two metallic portions of an installation that must be maintained at the same earth potential rules 5.3.1.1. 5.3.8.1.

Earthing Continuity

Refers to the necessity of making metallic cable sheaths or enclosures such as troughing or conduits, both mechanically and electrically continuous so as to provide a low resistance path for any fault current to earth. Sometimes referred to as the earth continuity fault path. (Rules 1.25. 3.25.9. 5.4.).

Short Circuit to Earth

Also called "Short to earth" or "Earth Fault" is one which causes a potential to earth resulting in fault current to earth.

Earth Fault Current

Current present in the earthing system caused by an earth fault.

Earthing Medium

Used to describe the nature of the conductive path to the main earth connection.
See S.A.A. Wiring Rules for permissible and non-permissible earthing medium.

Earthing Bar

Bar or link installed in a switchboard for the purpose of connecting earthing conductors. (Rule 5.3.1.1.).

Laid up Earthing Conductor

An earthing conductor enclosed within the same cable sheath as the associated live conductors.
Twin + Earth $1mm^2$ is a common example.

Earthing Terminal

The seperate terminal provided in accessories or an appliances for the connection of the earthing conductor. (Rules 5.3.2. 5.3.5. 5.3.6.).

Consumer's Earthing Systems

S.A.A. Rules allow 3 types of earthing systems.

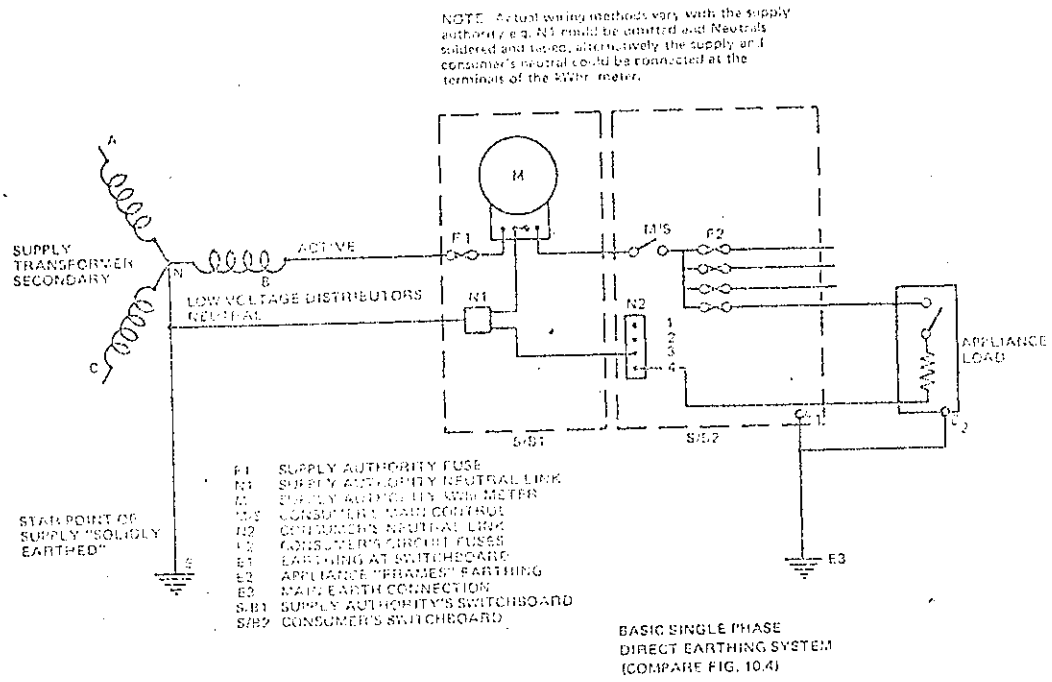
1. Direct Earthing System
2. Multiple Earth Neutral System (M.E.N.)
3. Earth Leakage Circuit Breaker (E.L.C.B.).

The most significant feature of these systems of earthing is the solid connection of the neutral star point to the general mass of earth at the source of supply which maintains the supply voltage to earth constant.

On rare occasions, a neutral not solidly earthed system may be encountered (Rule 2.17.). The earthing requirement at the consumer's premises will be the same as those applying to the Direct Earth Syst

Note: Not solidly earthed refers to the source of supply.

## Direct Earthing System




BASIC SINGLE PHASE DIRECT EARTHING SYSTEM (COMPARE FIG. 10.4)

Fig. 10.8 Direct Earthing System

This shows the connections on a small consumer's switchboard for a simple direct earthing system.

There is no connection between the neutral and earth at the consumer's installation.

It is the simplest system but the resistance of the return earth loop must be kept at low value and for this reason, most supply authorities only maintain the system in areas where a solid water reticulation scheme exists.

## M.E.N. System

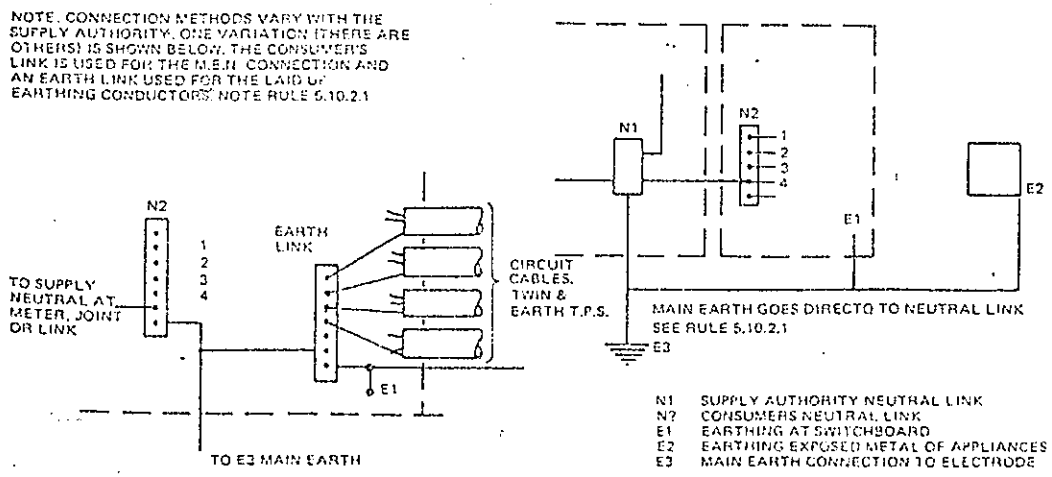


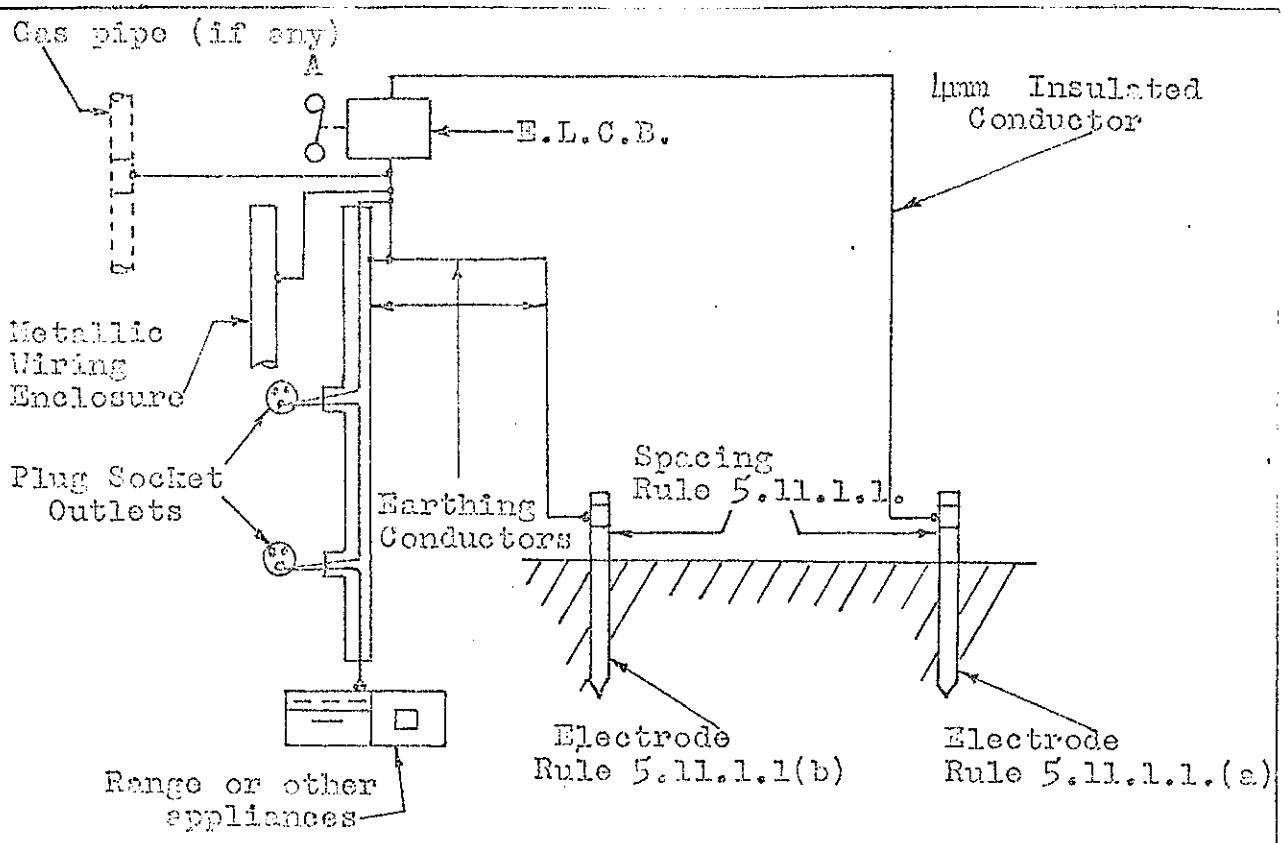

Fig. 10.9 MEN System of Earthing

This is the most widely adopted system. Supply Engineers consider that it's practical advantages outweigh it's disadvantages.

The only difference to the previous system as far as the consumer's installation is concerned, is that the main earthing conductor is taken direct from the earth electrode to the neutral link at the switchboard.

Each consumer's earthing system is connected in the same manner and this mutiple earthing of the neutral together with numerous earthing points on the supply side, gives the system it's name.

E.L.C.B.




CONNECTION OF EARTH LEAKAGE CIRCUIT BREAKER

- SIMPLE INSTALLATION

With either of the previous systems it is necessary for high values of fault current to be present before the protection will operate, hence they are "current-sensitive" systems and neither is effective against voltage rise in the earthing system unless the rise is due to high current, because V=IR low current coupled with high resistance, may cause a high voltage and possible electric shock.

The E.L.C.B. was introduced mainly as a protection against shock, leaving the over load to current devices.

Because of this, it may be considered as supplementary protection added to the direct earthing system.

The diagram shows the additional connections required to add E.L.C.B. protection to a direct earth system.

The trip relay operates between 20 and 26 volts to open the circuit.

This relay is connected between the earthing system and an auxillary earth electrode (Rule 5.11.1.).

Recently another type of Earth Fault Current Protection has been developed. The Core Balance Earth Leakage Protection (Scanelec Permat etc.).

This device has been made to offer protection against accidents which involve contact between a live wire and earth.

Protection is not afforededagainst simultaneous contact with active and neutral or two actives.

## Installing the Earthing System

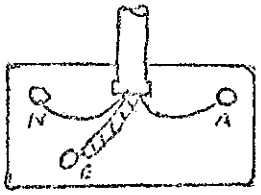
Apprentices should gain a basic understanding of general earthing requirements so that mistakes due to ignorance of these requirements will not occur early in their career.

Section 5 of the S.A.A. Wiring Rules deals with most of the rules relevant to the installation of earthing systems.

Rules 5.9 5.10 and 5.11 are additional rules, particular to each of the three earthing systems.

Observe that:

1. The third pin of all three pins plug sockets must be earthed.
2. All exposed metal as defined by Rule 0.5.44 must be earthed.
3. Metallic parts that have been earthed are not to be used as the earthing medium for other parts of equipment to be earthed.
4. Any bare earthing conductor up to 4mm connected behind a plug socket or switch must be sleeved or insulated (Rule 5.5.2.5.). This also applies to bare earthing conductor at the back of switchboard.




PROTECTION OF BARE EARTHING CONDUCTOR

## Supplementary System of Earth Protection

Three methods of achieving isolation of lives parts so that break down to earth is remote are:

1. By the use of all-insulated equipment
2. By the use of double insulating equipment
3. By insulation from supply using an "isolating transformer".

These topics are the subject of later detailed study. They are included here for their basic principles.

1. All Insulated equipment

This type of equipment is designed to ensure that there is no exposed external metal of any description.

2. Double Insulation

This system achieves the isolation of live parts by interposing two separate layers of insulation between the live parts and any external metal.

Both sets of insulation would have to break down to constitute a hazard.

Small appliances such as "Electric drills", "Sewing machines" and "Shavers" are usually double insulated. They are marked:

DO NOT EARTH. DOUBLE INSULATED

On no account should this instruction be disregarded as any earthing of external parts would actually introduce a hazard.

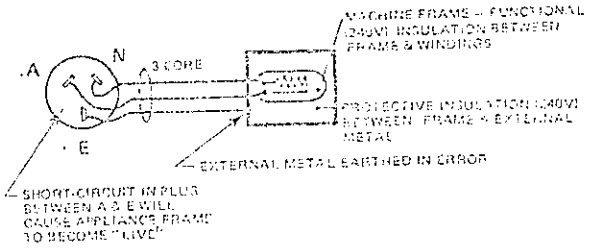



Fig. 10.20 How the earthing of a double-insulated appliance could create a safety hazard

## Insolating Transformers

This type of transformer has two electrically separate windings which ensures that there is no potential difference between the secondary supply terminals and earth or the primary supply making shock a hazard.

Only one appliance may be connected to the secondary, not because of over load, but because it could create a safety hazard under certain conditions.

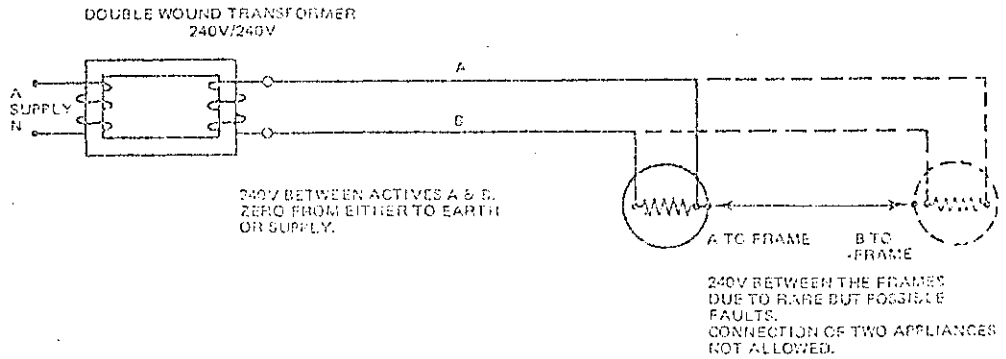



Fig. 10.21 Possible safety hazard created by using more than one unearthed appliance with an isolating transformer

## Resistance of Earthing System

The maximum resistance of the earthing system of an installation is specified as 2 OHM by rule 1.25 which also states that it's value must be low enough to permit sufficient fault current to operate the protection.

To ensure that the rule is complied with, the resistance of the earthing system of an installation must be tested. The object of the test is to determine the resistance value of the earthing system between the main earth connection and any part of the system.

For example: The earthing terminal of a three pin plug - the frame of a fluorescent luminair - the frame of a motor.

If an M.E.N. system is employed, then this test is from any part of the earthing system as before to the main earth connection at the NEUTRAL LINK.

In addition, the resistance value from the neutral to the earth electrode must be within 2 OHM.

When carrying out earth resistance tests, the metal frames of all appliances and luminaires should be checked because they are mass produced and it could happen that the resistance between earthing terminal and frame (0.1 OHM or less) is higher than specified by "S.A.A. Rules, part 2 ASC 100".

The process of painting often affects the earth continuity between frames and parts.

Most appliances are handled while in operation, so it is essential to have an effective earthing of the appliance.

Visual inspection of the earthing system should also be made where possible on new and existing installations.

Any apparent high resistance point should be checked and corrected if necessary.

TITLE:- S.A.A. WIRING RULES

LECTURER:- GECRU HEUNIS

DATE:- 22-6-81

EQUIPMENT:- Figure 8, V.I.R. cable, T.R.S. cable, P.V.C. cable, C.T.S. cable, P.I.L.C. cable, varnished cambric.

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## CABLE TERMINOLOGY

Conductor-S.A.A. 0.5.24:-
A wire, or other form of conducting material, suitable for carrying current, but not including wire or other metallic parts, directly employed, in converting electrical energy into another form.

Bare conductor-S.A.A. 0.5.25:-
A conductor without covering or insulation.

Active conductor-S.A.A. 0.5.4:-
Any one of those conductors of a supply system, which is maintained at a difference of potential, from the neutral or earthed conductor. In a system which does not include a neutral or earthed conductor, all conductors shall be considered active conductors.

Neutral conductor-S.A.A. 0.5.58:-
The conductor of a 3 wire or multi-wire system, which is maintained at an intermediate, and approximately uniform potential, in respect of the active or outer conductors, or the conductor of a two-wire system, which is earthed at its origin.

Earth conductor-S.A.A. 0.5.38:-
A conductor connecting any portion of the earthing system, to the portion of the installation or apparatus required to be earthed, or, to any other portion of the earthing system.

Cable-S.A.A. 0.5.16:-
One insulated conductor (solid or stranded) or two or more such conductors, laid together either with or without bare conductors, fillings reinforcements, or protective coverings.

Flexible cable - S.A.A. 0.5.19:-
A cable, the conductors, insulation and covering of which, are such as to afford flexibility.

Flexible cord - S.A.A. 0.5.28:-
A flexible cable, no wire of which exceeds 0.30 mm diameter, and no conductor of which exceeds 4mm$^2$ cross-sectional area, and having not more than five cores.

## COMMON TYPES OF POWER & LIGHTING CABLES

Rubber:- Will withstand temperatures of approximately 50°C, but beyond this it becomes damaged.

Vulcanised India Rubber (V.I.R.):-
Cable becomes damaged at about 60°C, and also by water and oils.

Tough rubber sheathed (T.R.S.):-
These have the conductors laid side by side for twin, or 3 cored flat cables. When the cable contains a bare earthing conductor, it is placed between the insulated cores.

Thermoplastic insulated (P.V.C.):-
Used as an alternative to rubber insulated cable. They have the advantage of being oil and moisture resistant, and are unaffected by corrosive conditions and direct sunlight.

Cab Tyre Sheathed (C.T.S.):-
Are twisted together, to form 2, 3, 4 or 5 core cables. During the process, a jute worming is used to fill the spaces between conductors, and gives a perfectly round surface, the cable is then covered with an outer tough rubber sheath, for mechanical protection.

Varnished cambric:-
Resists oil better than rubber, and will withstand temperatures up to about 70°C. This type of cable has approximately 20% higher current rating than V.I.R. cable, and is mainly used for wiring oil-immersed switch gear, switchboard wiring, and for high voltage cables.

Paper insulated lead covered(P.I.L.C.):-
Most modern power distribution cables are insulated with impregnated paper. As the paper absorbs moisture, and the conductor is required to be screened from external electric fields, the cable is lead sheathed. This lead sheath is earthed. The capacitance between conductor and sheath is appreciable, and care should be taken when handling this type of cable until it has been properly discharged. It will not withstand sharp bending or vibration, without the possibility of fracturing.

## Factors to be considered when selecting a cable for a particular job.

(1) Current carrying capacity.(cross sectional area).
(2) Resistance of the run (lead & return, affect voltage drop and power loss).
(3) Insulation resistance (must be able to withstand peak supply voltage).
(4) Mechanical features (strength, flexibility, weight etc.).
(5) Probable future loading requirements.
(6) Initial, and maintenance costs.
(7) Fire and safety risks.
(8) Local conditions i.e., mechanical damage, extreme temperatures, injurious atmosphere.
(9) All relevant S.A.A. and supply authority rules and regulations covering the installation.

## DISTINGUISHING CABLE COLOURS: S.A.A. 3.1

General:- The colour GREEN, or a combination of GREEN/YELLOW shall not be used to identify any conductor, other than an EARTHING CONDUCTOR.

The following colour coding of the cores of FLEXIBLE CORDS, is being adopted in several countries (including the U.K.) and accepted for use in Australia -

Sheath: Black
Single Core: Brown (active), Light Blue (Neutral), or, for earthing conductors, Green or Green/Yellow.
2-core: Brown (active), Light Blue (neutral)
3-core: Brown (active), Light Blue (neutral) and for earthing conductors, Green or Green/Yellow.
OR, Brown, Black, Yellow (actives), Light Blue (neutral)
4-core: Brown, Light Blue, (actives) and for earthing conductors, Green or Green/Yellow.
5-core: Brown, Black, Yellow (actives), Light Blue (neutral), Green or Green/Yellow (earth).
OR, Brown, Yellow, Black, (actives) Light Blue (neutral)

Voltage drop - S.A.A. 3.1.3.
This section deals with the fall in voltage, from the commencement of the consumers mains, to any point on an installation. Information on voltage drop, including a method for choosing conductor sizes taking into account voltage drop, is given in Appendix B.

Current rating - S.A.A. 2.1.2.

Except as varied in a particular rule, every conductor shall have a current-carrying capacity, at least equal to the current to be carried by it.

S.A.A. 2.4 - Method of determining maximum demand in mains and sub-mains.

S.A.A. 2.8 - Maximum demands in final sub-circuits.

TITLE:- S.A.A. WIRING RULES (SWITCHBOARD CONSTRUCTION)

LECTURER:-

DATE:-

EQUIPMENT:- Zelemite panel, fuses, neutral link, earth bar, bus-bar, switch board identification tabs.

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2.21.1. Spacing of apparatus:-
To ensure safe operation and handling.

2.21.2. Switchgear-mounting:-
Refers to material used for mounting panels.

2.21.3. Switchboard-panels:-
Material used for panels and thickness.

2.21.5. Apparatus-mounting:-
Spacing and fixing apparatus.

2.22.1. Protection of switchboards against spread of fire:-
Wiring enclosures - distance from wooden floors - apertures - flammable material.

2.23.1. Protection against risk of shock:-
Live parts exposed - wire spacing - enclosing live parts.

2.24.1. Accessibility:-
Provision for replacements - doors - distances - clearances.

2.24.2. Switchboards with removable or hinged panels:-
Max. size - clearances - distortion - angle of swing - support.

2.24.4. Fixed switchboards with access from edges:-
Spacing and clearances for safe access.

| 1 | 2 | 3 |
|---|---|---|
| Distance from any point on the switch-board, to the nearest means of access | Minimum clearance behind switchboards | Minimum space adjacent to point of access |
| m | m | m |
| Not exceeding - | | |
| 0.3 | 0.1 | 0.23 |
| 0.45 | 0.15 | 0.23 |
| 0.6 | 0.23 | 0.3 |
| 0.75 | 0.3 | 0.3 |

2.24.5. Fixed switchboards with access from rear:-
Spacings - clearances - access - enclosing - locking.

2.25.1. Arrangement of apparatus on switchboards:-
Marking and identifying - links - fuses - switches.

2.25.2 Mounting of fuses:-
Restricted mounting - fuse arrangement - covers.

2.25.3 Fuses on back of switchboard:-

2.25.4 Clearance from bare conductors & live parts:-
Clearances - fixing - busbars - supports - rewirable fuses - manufactured apparatus.

3.25.5. Neutral bars and links:-
Connecting - current carrying capacity - minimum size - terminals - outbuildings - marking under MEN system - enclosing - accessibility - location.

3.26. Wiring of switchboards:-
Enclosure and protection - holes in panels - switchboard covers - arrangement sequence - sleek wire - fastoning - pressure on conductors.

3.27. Alterations to switchboards:-
Location - layout - reconstruction.

3.28. Control panels:-
Installation - access to front and roar - protection against spread of fire and risk of shock.