UNDERSTANDING OF SS 638 & SS 650 Parts 1 & 2

Refresher Course for Licensed Electrical Workers

Chan Chee Hin
2023

Legislation Governing Electrical Installations

- ELECTRICITY ACT (CHAPTER 89A),
  - Section 103 – …. the Authority may … make regulations for the regulation of the installation of electrical installations and alterations thereto and the submission of plans and specifications…
- Electricity (Electrical Workers) Regulations
  - Regulation 5 states the authority conferred by licence – i.e. Electrician's Licence, Electrical Technician's Licence and Electrical Engineer's licence
- ELECTRICITY (ELECTRICAL INSTALLATIONS) REGULATIONS Regulations 13 (2), 13(3) & 13(4)
  - The LEW responsible for the installation … shall ensure that such electrical installation complies with the Singapore Standard SS 638 & 650 Parts 1 & 2

Legislation

- Electricity (Electrical Installations) Regulations
  - Section 40
    - Any person who contravenes regulation .. 13.. Shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $5,000 and in the case of a continuing offence, to a further fine not exceeding $150 for everyday .. Which the offence continues after conviction.

SS638 - SCOPE, OBJECT AND FUNDAMENTAL PRINCIPLES

- Ensure safety, especially protection against electric shock and fire in the use of electricity
- Provide guidance in the Design of electrical installation to ensure safety and proper functioning of electrical installation for the intended use
- Selection, Erection, Inspection and Testing of electrical equipment – does not deal with requirements for the construction of assemblies of electrical equipment (which are required to comply with appropriate standards)

Installations Excluded from SS638

- Systems for the distribution of electricity to the public
- Railway traction equipment, rolling stock and signaling equipment
- Equipment on board ships
- Equipment of mobile and fixed offshore installations
- Equipment of aircraft
- Radio interference suppression equipment, except so far as it affects safety of the electrical installation
- Lightning protection systems for buildings covered by SS 555.
- Those aspects of lift installations covered by SS 550 (Installation, operation and maintenance of electric passenger and goods lifts)
- Electrical equipment of machines covered by IEC 60204

Relationship with Statutory regulations

- Compliance with SS 638 (formerly CP5) and SS 650 Parts 1 & 2 (formerly CP 88 Parts 1 & 2) are made mandatory under the Electricity (Electrical Installations) Regulations with effect from 15 Nov 2019.

Contents of SS638

- Part 1 - Scope, Object And Fundamental Principles
- Part 2 - Definitions
- Part 3 - Assessment of General characteristics
- Part 4 - Protection for Safety
- Part 5 - Selection and Erection Of Equipment
- Part 6 - Inspection and Testing
- Part 7 - Special Installations or Locations
- Annexes
- Appendices

Some of the Changes in SS 638

New Definitions

Basic protection (formerly in CP5 known as protection against direct contact). Protection against electric shock under fault-free conditions (i.e. protection against direct contact that is "contact of persons or livestock with live parts")

Fault protection (formerly in CP5 known as protection against indirect contact). Protection against electric shock under single fault conditions

General changes and update on all Parts

These include design and safety requirements and numbering system

Arrangement of the Parts

Inspection and Test – Part 7 of CP5, Part 6 in SS 638

Additional sections and changes to Part 7 (special installations)

a. Locations containing a bath or shower
b. Swimming pools and other basins
c. Solar photovoltaic power supply system
d. Outdoor lighting installations

e. Extra-low voltage lighting system
f. Operating and maintenance gangways

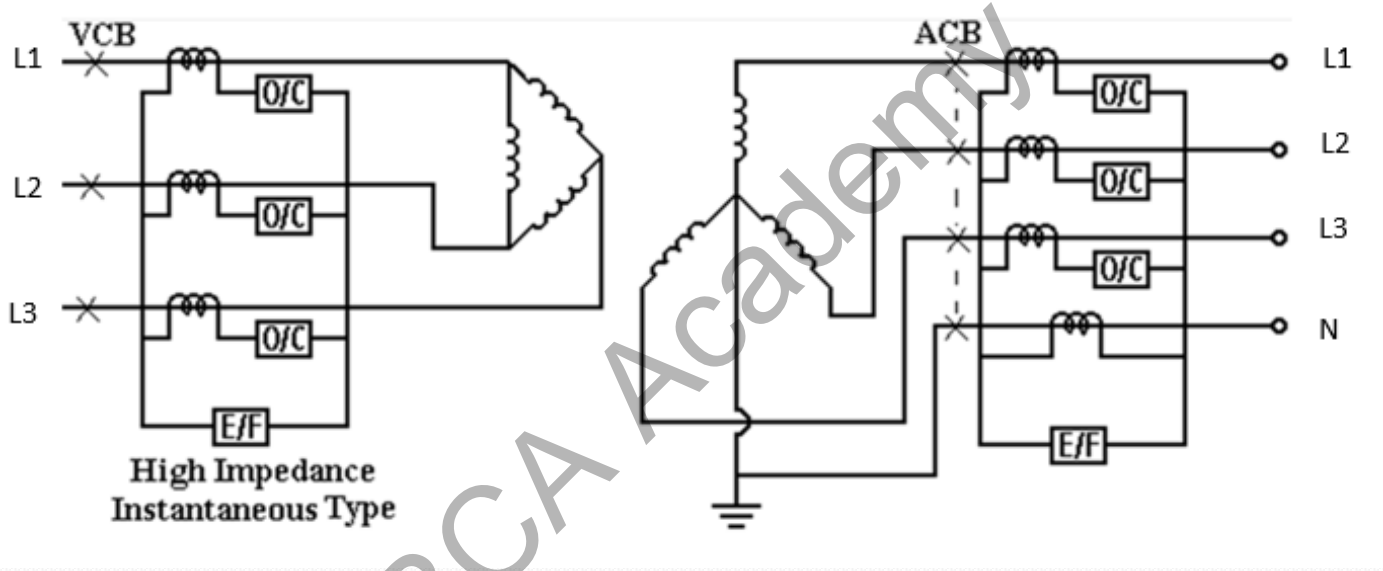
New annexes

a. Medical locations
b. Revised cable colour code

New appendices

a. Current-carrying capacity of& voltage drop for busbar systems
b. Protection of conductors in parallel against overcurrent
c. Effect of harmonic currents on balanced three-phase systems
d. Devices for protection against overvoltage

Fundamental Requirements For Safety



3 Elements:

- (1) Overcurrent protection
- (2) Earth leakage and earth fault protection
- (3) Isolation & Switching

Overcurrent Protection

Every Installation & every circuit shall be protected against overcurrent by devices which:

(i) Will operate automatically

(ii) Are of adequate breaking capacity

(iii) Are suitably located and constructed

Earth fault and earth leakage protection

- Metalwork of electrical equipment shall be connected with earth
- The circuits shall be protected against the persistence of an earth fault current by:
  a) The overcurrent protective devices or
  b) Additional protection by residual current device if the prospective earth fault current is insufficient to cause prompt operation of the overcurrent protective devices.

Isolation and Switching

- Effective means to cut off all voltages from every installation

Devices for Isolation

- Isolate all live supply conductors from the circuit concerned.
- The clearances and creepage distance for isolation (switch disconnector) in accordance with IEC 60947-3.
- Circuit breaker suitable for isolation in accordance with IEC 60947-2 identified by symbol 
- Note: Semiconductor devices shall <u>not</u> be used as isolating devices

Isolation

Means of isolation shall be provided

1. At the origin of the installation
2. For every circuit
3. For every item of electrical equipment
4. For every motor circuit
5. For every supply source

Isolation of Neutral at Main Switch

- A main switch intended by unskilled persons, shall interrupt both live conductors of a single phase supply

- It is not necessary to provide overcurrent detection for the neutral conductor or a disconnecting device for that conductor if the size of the neutral conductor is similar to the line conductors

Emergency switching

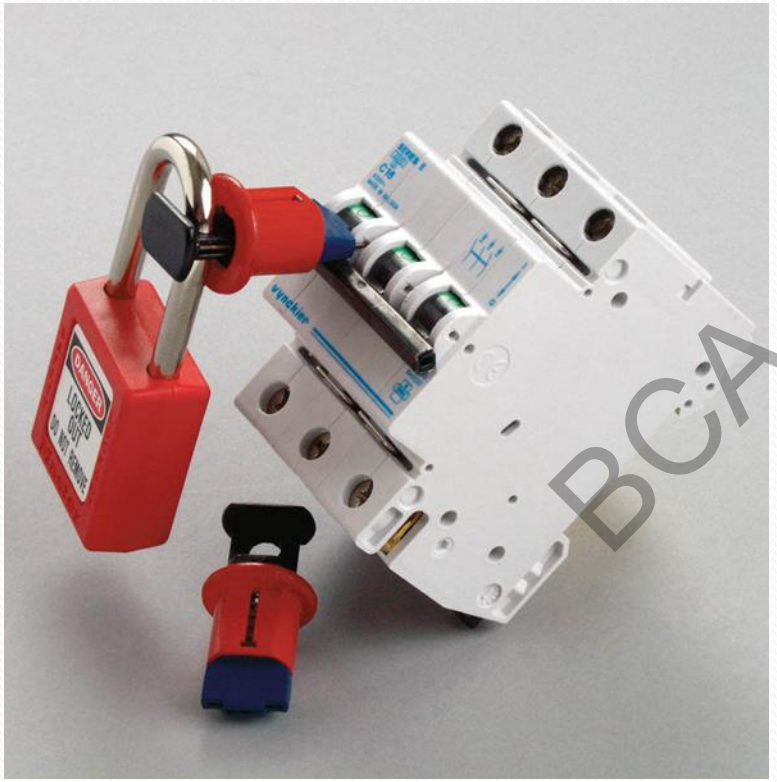
- Where a risk of electric shock or unexpected danger Emergency Switching shall interrupt all live conductors
  - Shall act as directly as possible
  - Only a single initiative action is required

Lockout Procedure (SS 571)

- Before any electrical work is to be carried out on the electrical installation, proper lockout/tagout (LOTO) procedure shall be adhered to by the Licensed Electrical Worker taking charge of the electrical work.

- The lockout/tagout procedure helps to prevent any possible electrical mishap caused by unexpected energisation

MCB and MCCB Lockout

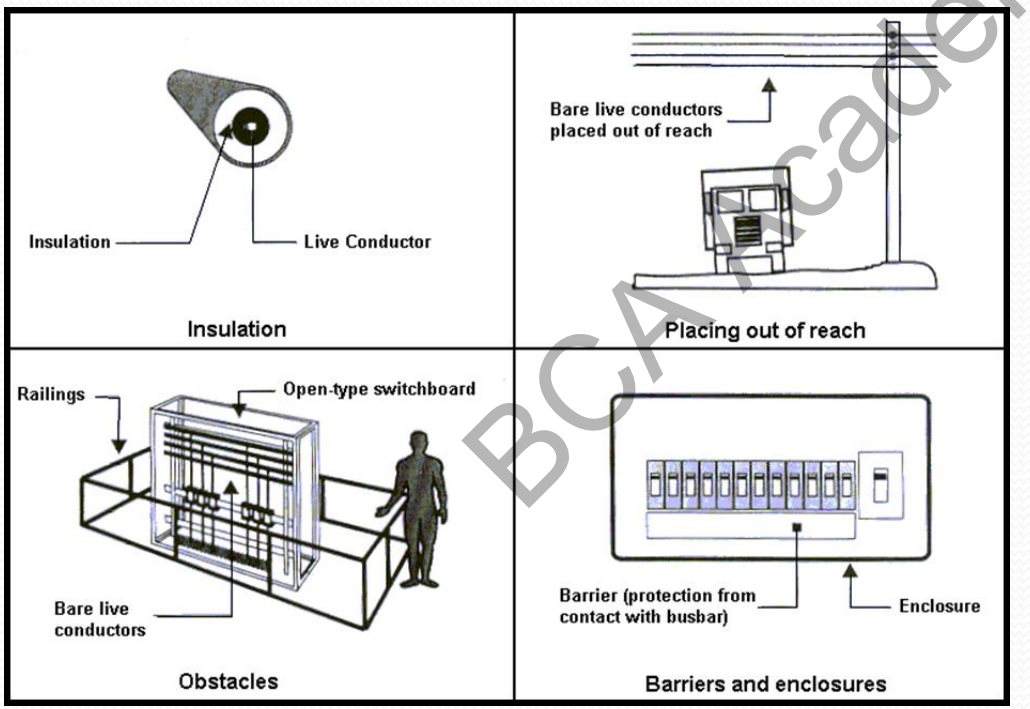



480 VOLT
PUMP #8
DANGER
DO NOT OPERATE


DANGER
DO NOT OPERATE
This lock/tag may only be removed by:
Name
Dept.
Expected Completion

Basic protection - Protection against Direct Contact

- Four basic measures for protection.
- Use of RCDs as supplementary protection.



Examples of the four basic measures for protection

General Requirements for protection against electric shock

A protective measure shall consist of:

1. An appropriate combination of basic protection and an independent fault protection, or
2. An enhanced protective provision (such as reinforced insulation) which provides both basic protection and fault protection

The following protective measures generally are permitted:

(i) Automatic disconnection of supply (section 411)

(ii) Double or reinforced insulation (e.g. Class II equipment) (section 412)

(iii) Electrical separation for the supply to one item of current carrying equipment (section 413)

(iv) Extra-low voltage (SELV and PELV) (Section 414)

Automatic Disconnection of Supply

This is a protective measure in which:

i. Basic protection is provided by basic insulation of live parts or by barriers or enclosures; and
ii. Fault protection is provided by:
    a. Protective earthing;
    b. Protective equipotential bonding; and
    c. Automatic disconnection in case of a fault - this is achieved by the provision of the following devices:
        - an overcurrent protective device and
        - a residual current device (complying to SS97 and with a tripping sensitivity of 30mA)

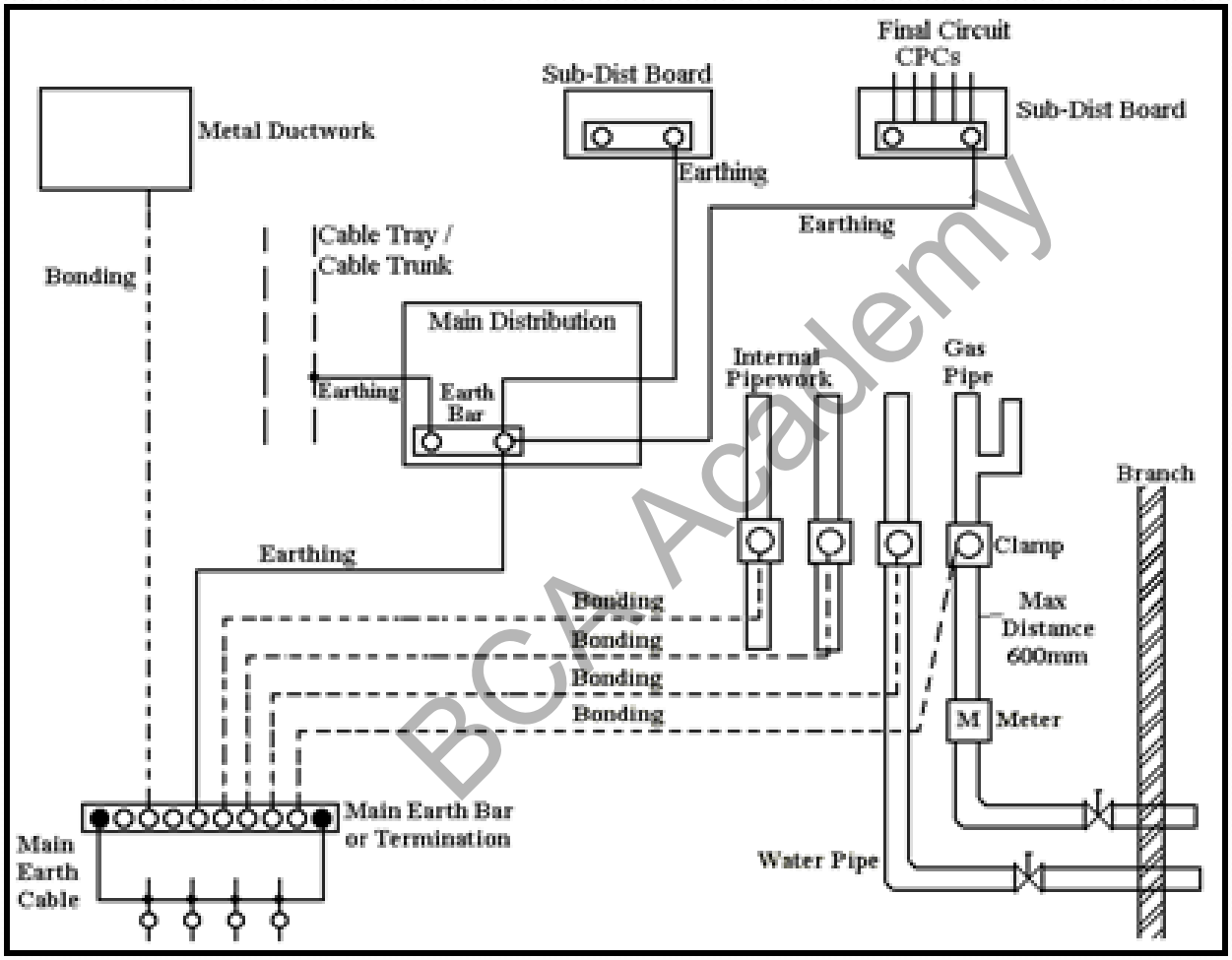
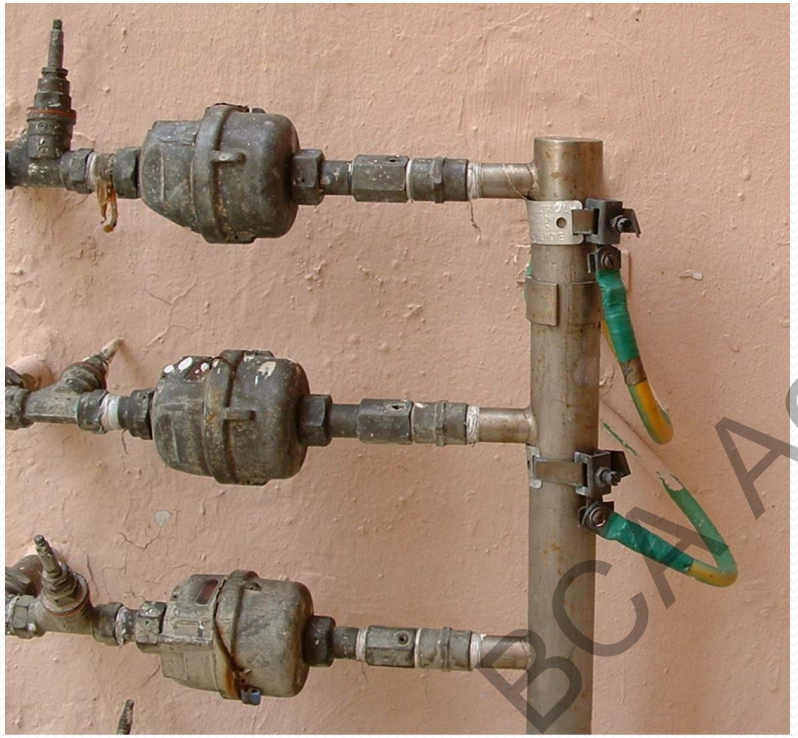
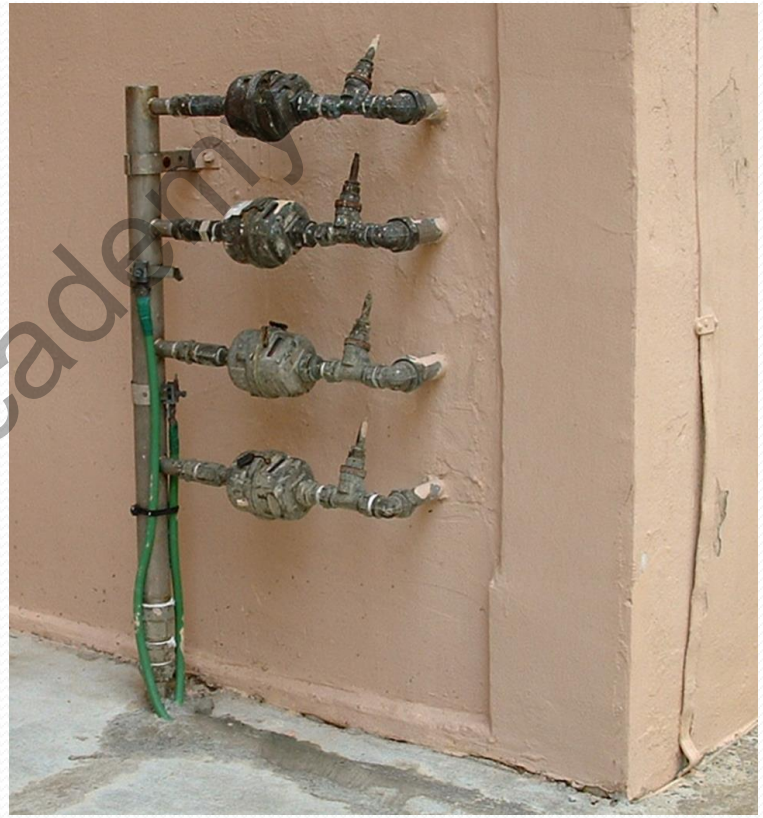


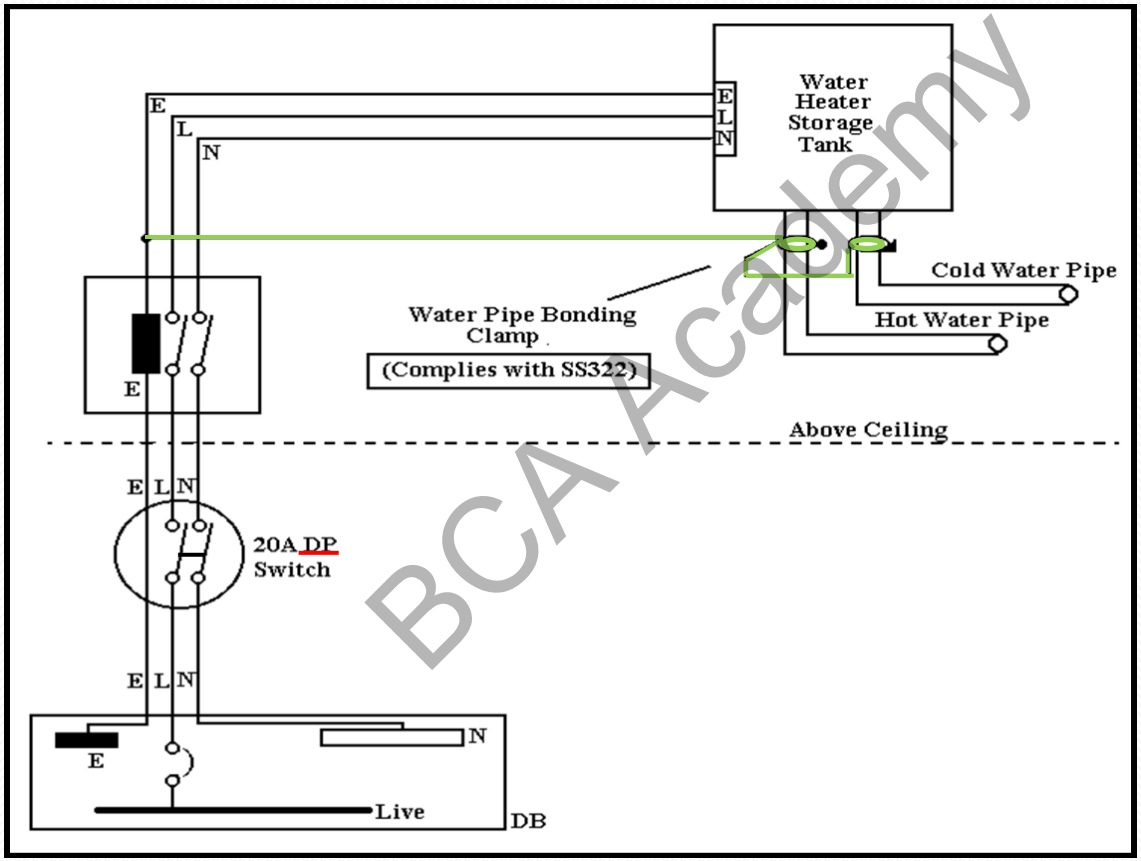
Figure – Earthing & Main Equipotential Bonding

Main Equipotential Bonding

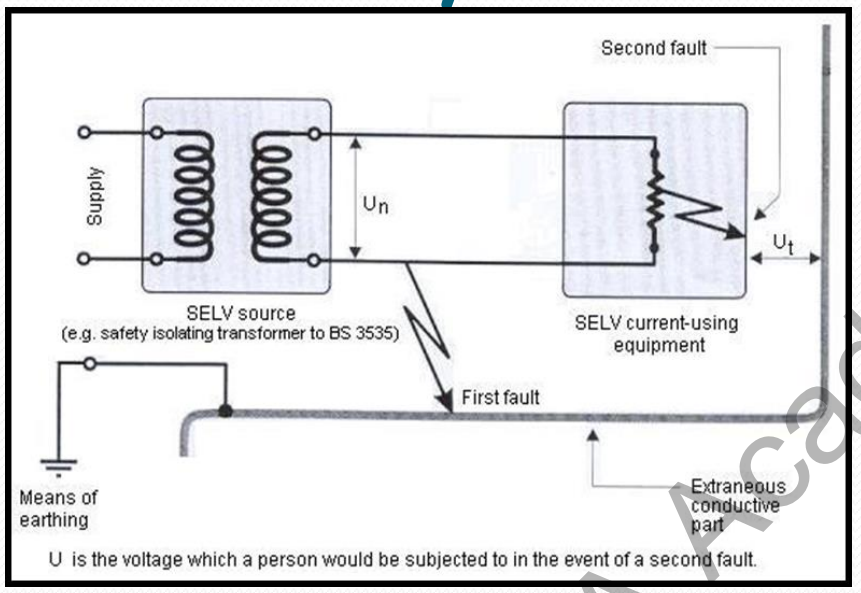




Supplementary Bonding of Water Pipes of Water Heater



Protection by SELV



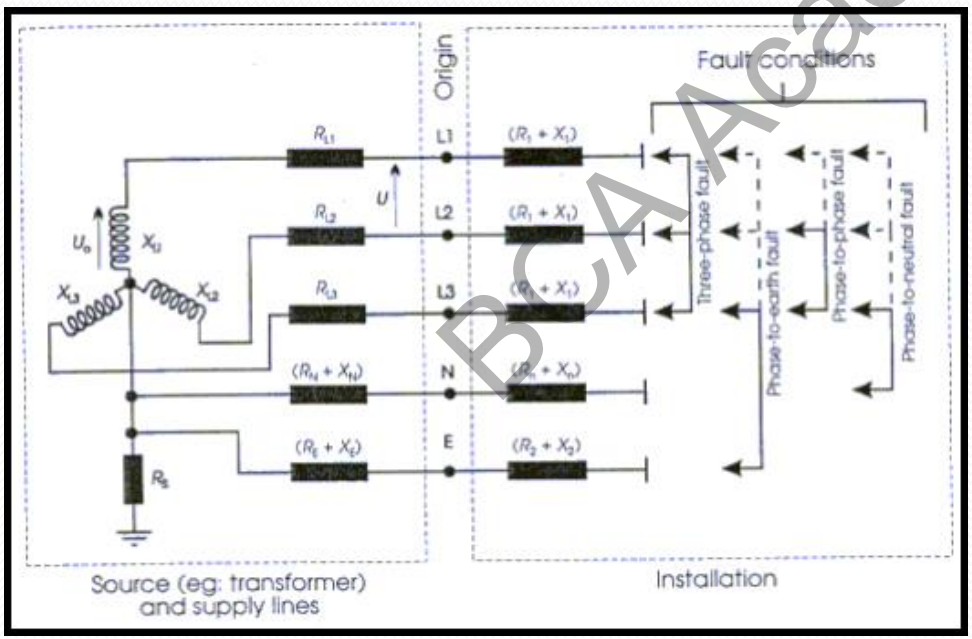
- Extra low Voltage. Normally not exceeding 50 V a.c. or 120 V ripple free d.c., whether between conductors or to Earth.
- SELV (separated extra-low voltage). An extra-low voltage system, which is electrically separated from Earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock.

Protection Against Overcurrent

Overcurrent is a current greater than the rated current of a circuit. It may occur in two ways: -

(a) As an overload current, or

(b) As a short-circuit between phases, between phases to neutral or between phases to earth.



Overcurrent Protection Devices

Disconnection of circuit if current exceeds a predetermined current value and time

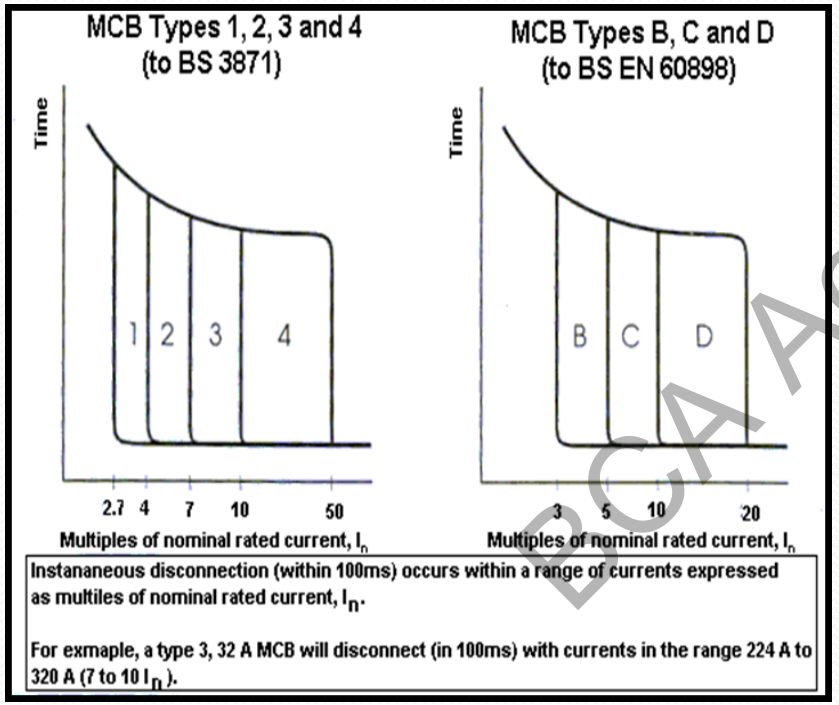


Figure – MCB characteristics

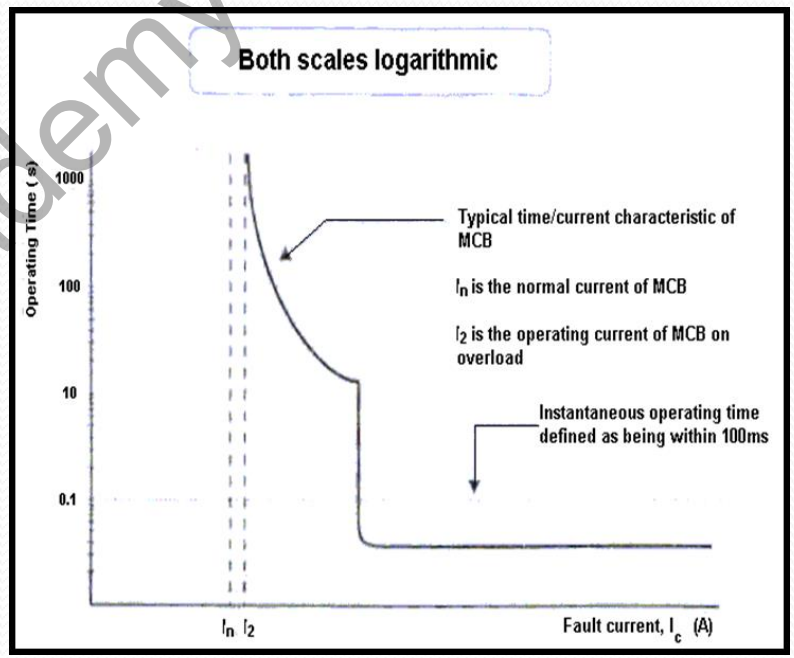
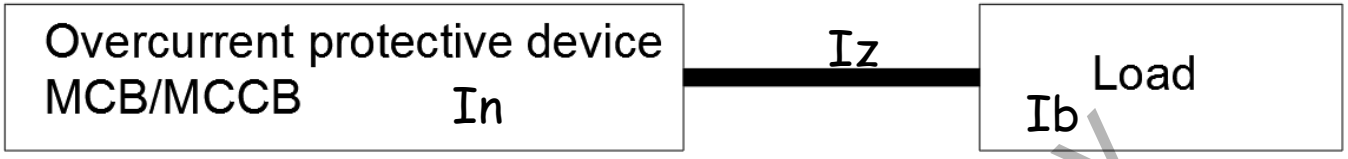


Figure – Typical operating characteristics of an MCB

Cable sizing



In is the rated current of the protective device
Ib is the design current
Iz is the current carrying capacity of the conductor
I_2 is the current causing the effective operation of the protective device

$Ib \leq In \leq Iz$
$I_2 \leq 1.45Iz$

Short Circuit Consideration for cable sizing

- Consider four parameters: current, duration, cable size and cable type
- The formula used is $k^2S^2 > Isc^2 t$ or $S = \sqrt{(I^2t)}/k$

where:

- t is the trip duration in seconds,
- S is the nominal cross sectional area of conductor in mm2,
- Isc is the value of fault current in amperes
- K is a factor depends on cable type

TWO Earthing Systems Allowed

- TN – S System
- TT System

TN-S Earthing System

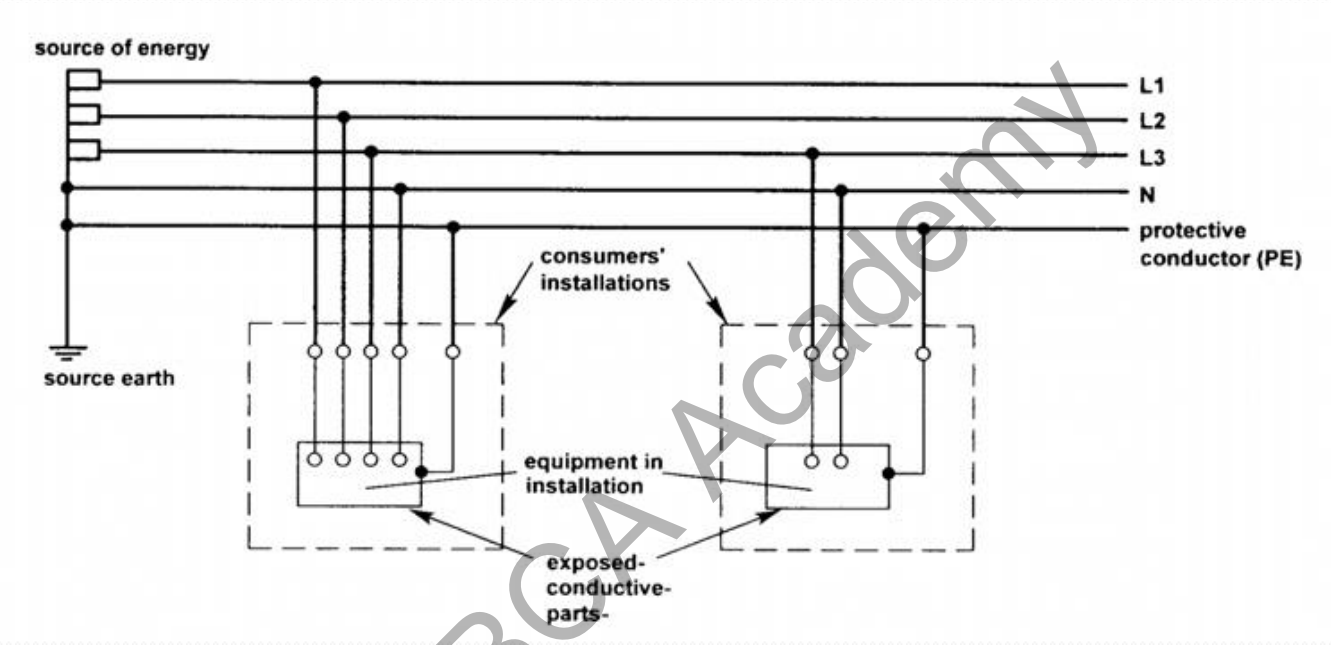
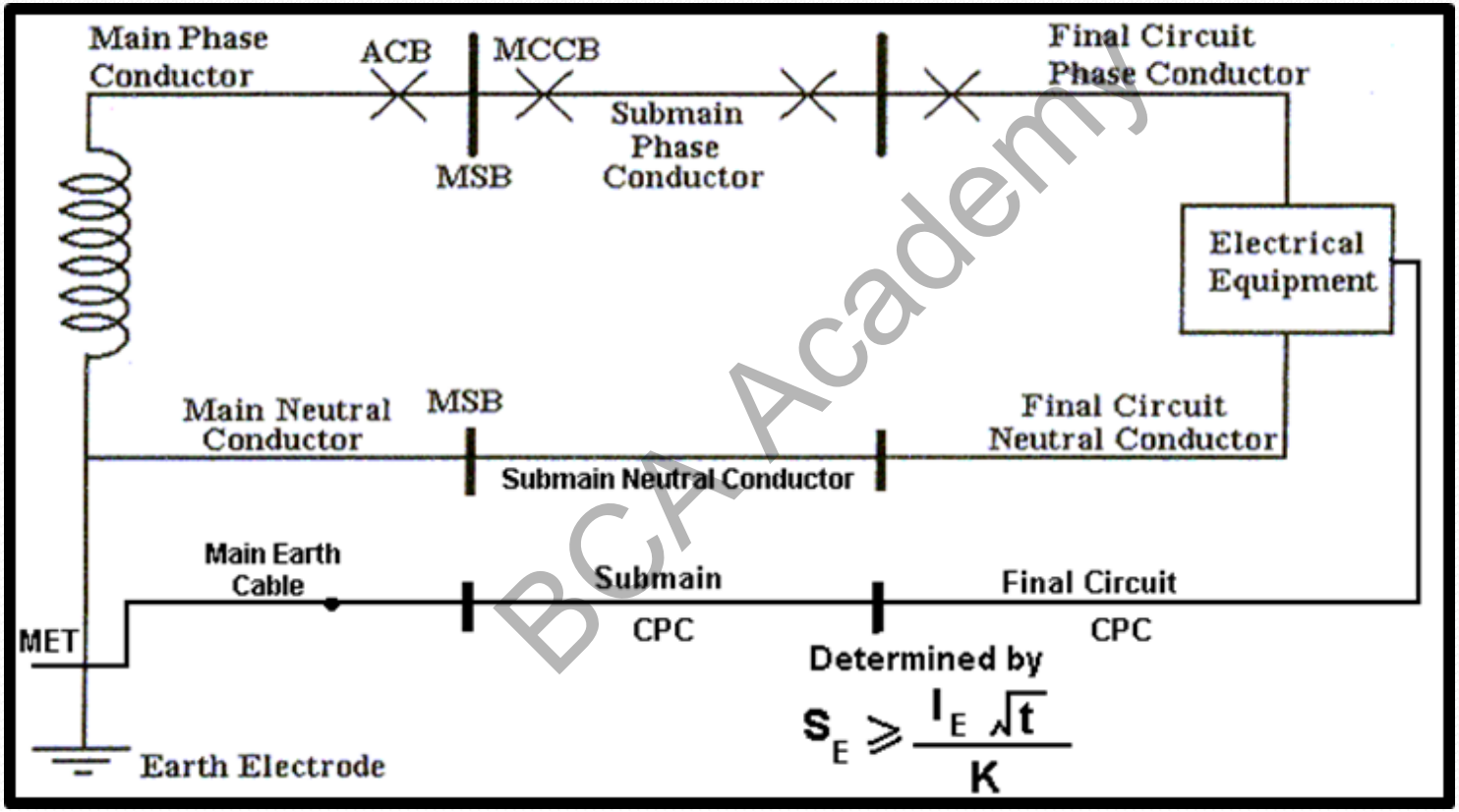


Figure for TN-S system

Note: Separate neutral and protective conductors throughout the system

TN-S Earthing System



TT Earthing System

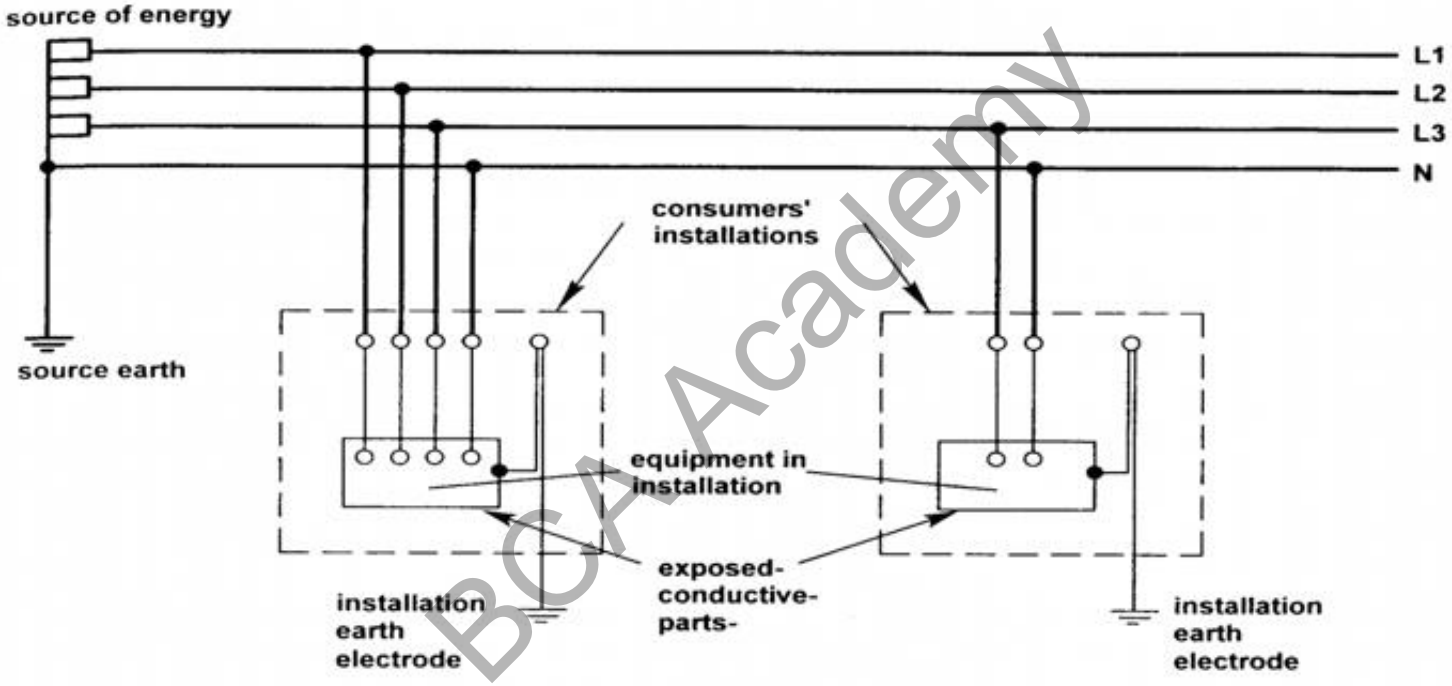
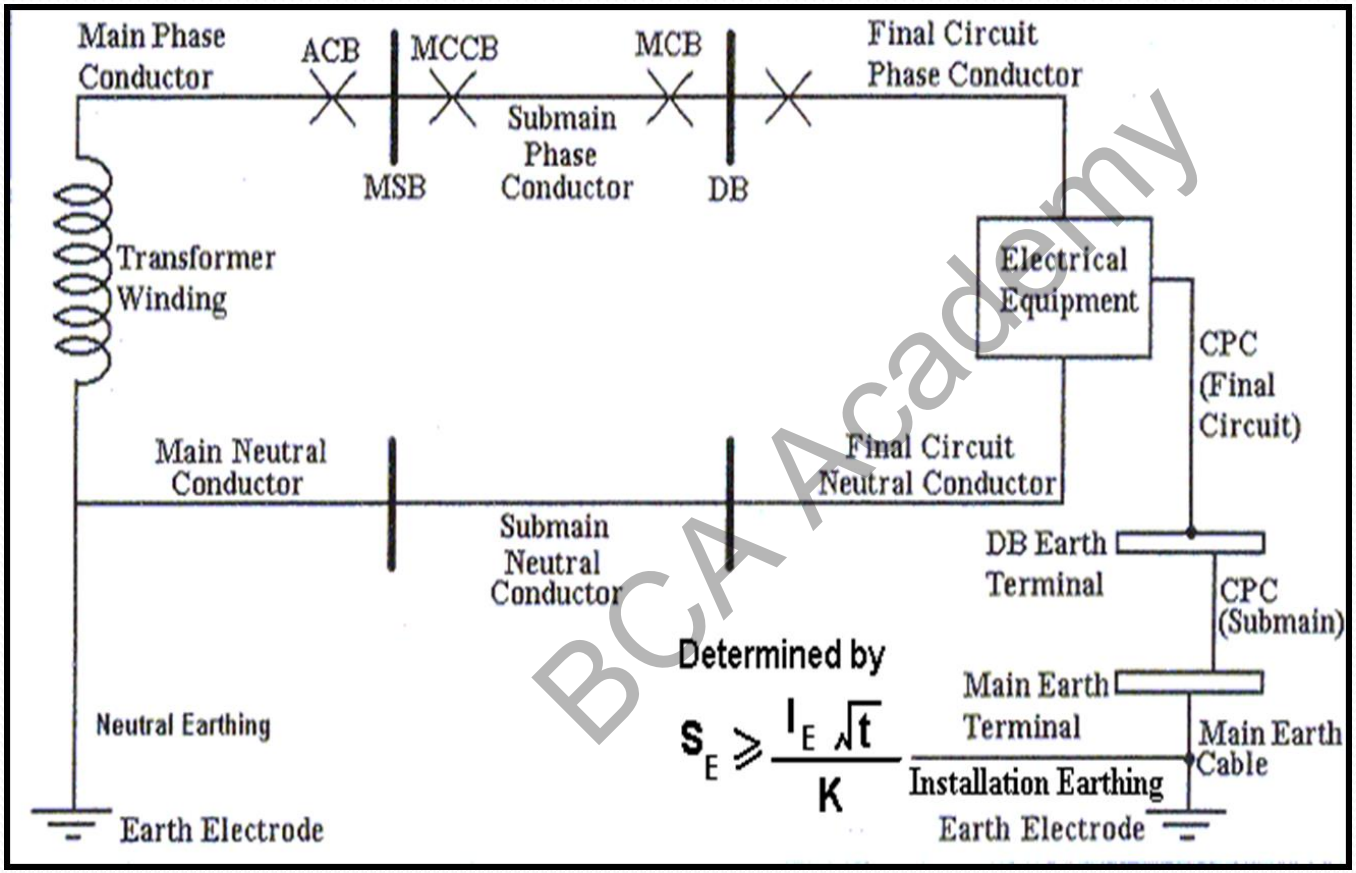


Figure for TT system

All exposed-conductor-parts of an installation are connected to an earth electrode which is electrically independent of the source earth

Note: Only TN_S & TT systems shall be allowed in Singapore

TT Earthing System



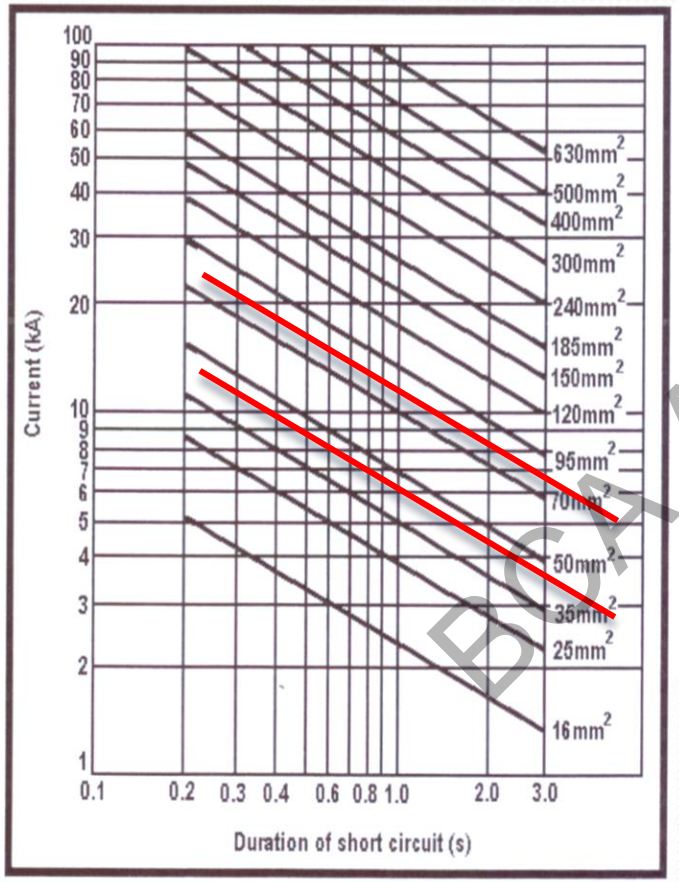
CPC for Final Circuits and Submains

(i) By calculation
(ii) From table 54.7

Phase conductor size (S), mm^2	Minimum CPC size, mm^2
$S \leq 16$	S
$16 < S \leq 35$	16
$S > 35$	S / 2

Minimum cross-sectional area of CPC in relation to cross-sectional area of phase conductors

Fault Level Withstanding Capability of Cables



$$S^2K^2 = I^2t$$

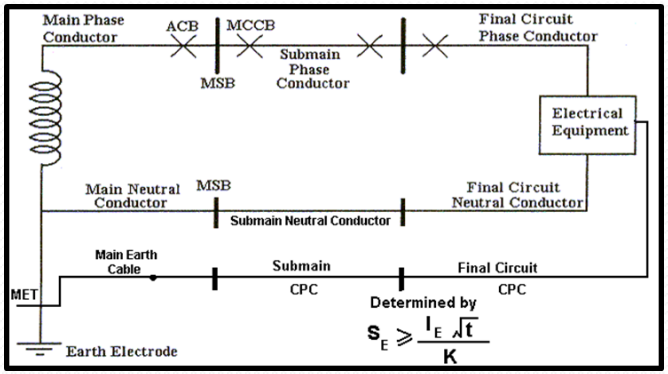
For XLPE/PVC k=143
For PVC k=115

Protection Against Electric Shock

TNS Earthing System

The following condition shall be fulfilled:
$Zs \times I\Delta n \leq 50V$

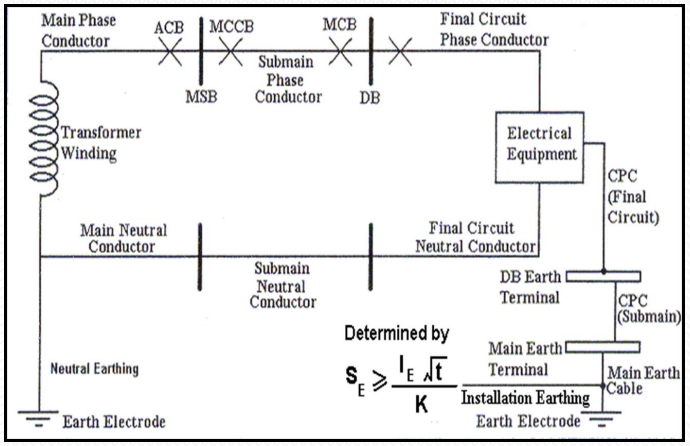
Where
Zs is the total earth loop fault impedance
$I\Delta n$ is the operating current of the RCD



Protection Against Electric Shock

TT Earthing System

The following condition shall be fulfilled:
$Ra \times I\Delta n \leq 50V$
Where
Ra is the total earth loop fault impedance which includes the earth electrodes resistance
$I\Delta n$ is the operating current of the RCD



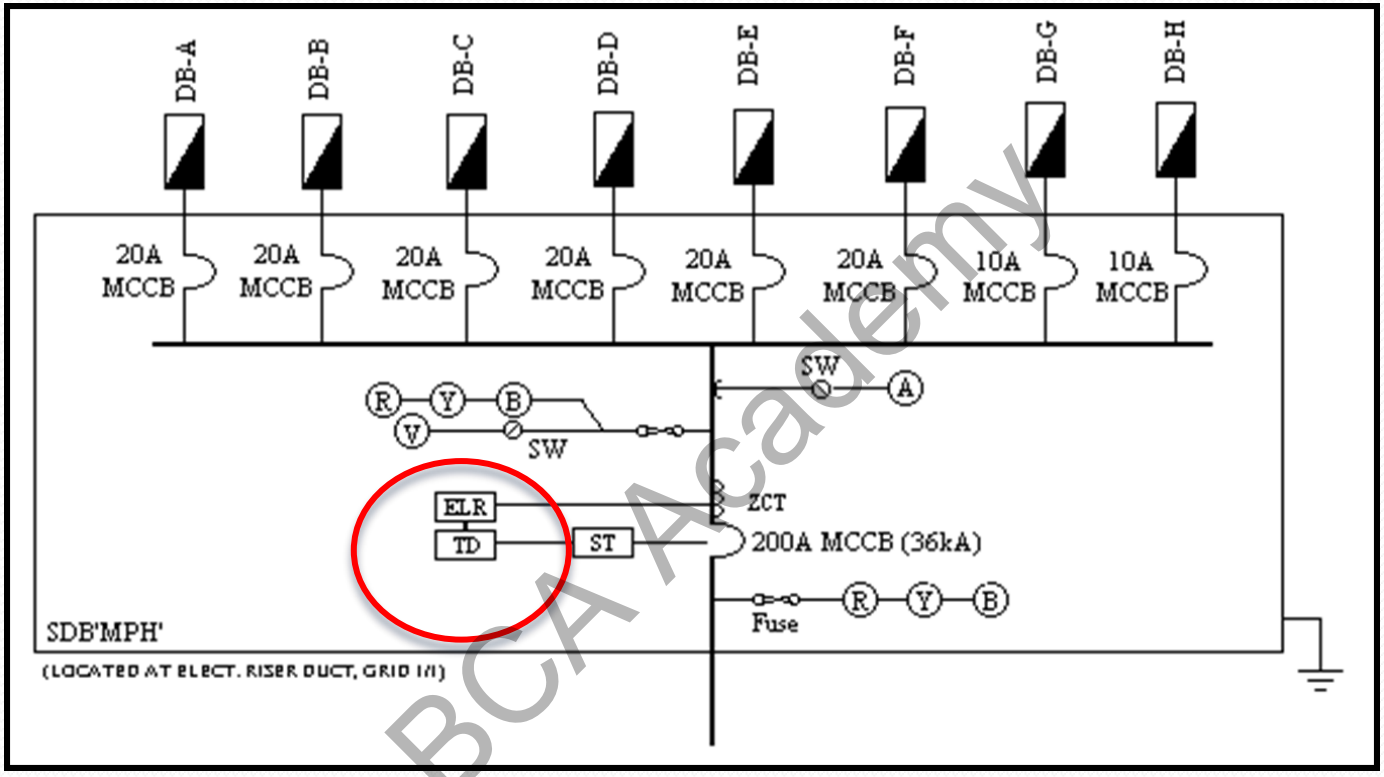
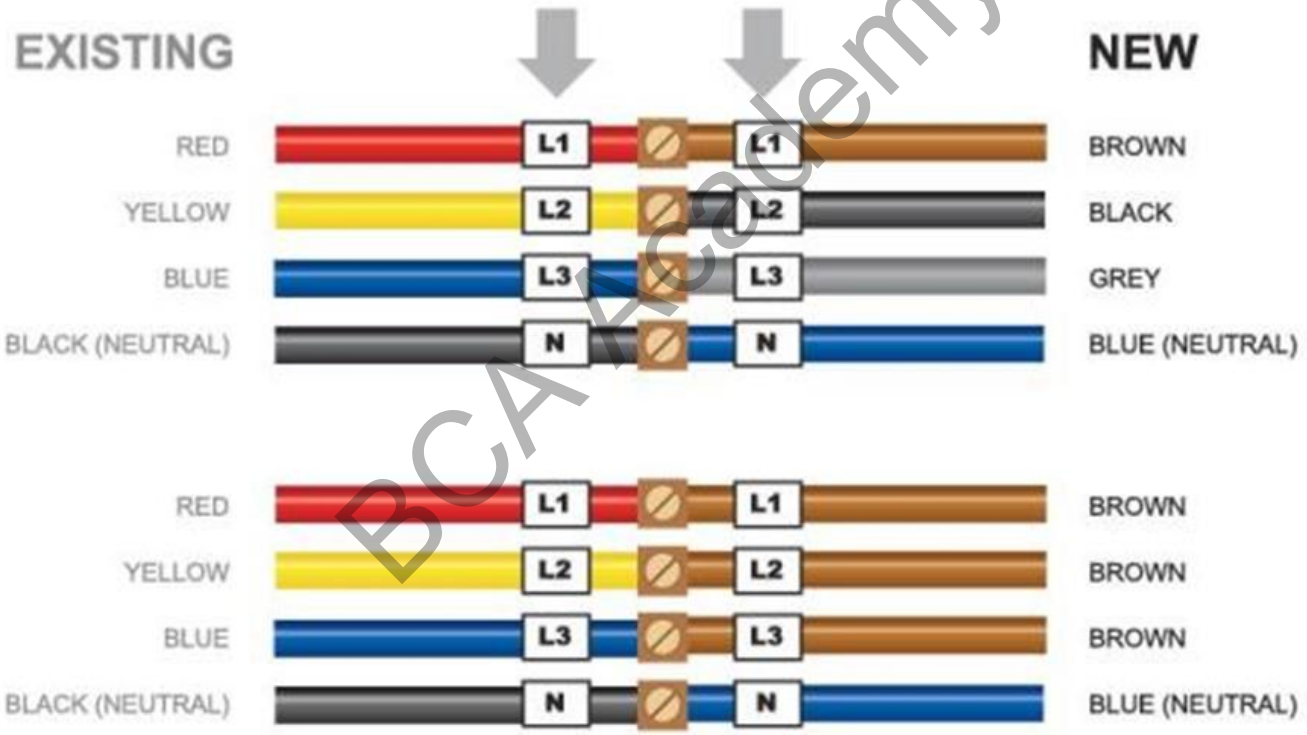


Figure for ELR used to provide protection against indirect contact by automatic disconnection

GUIDE TO COLOUR MARKING FOR THREE-PHASE CIRCUITS

Durable and legible markings shall be provided at the interface where the new and old versions of colour code for fixed electrical wiring exists.

A warning notice (see Figure 1 on page 10) shall also be displayed prominently at the appropriate distribution board that controls the circuit.

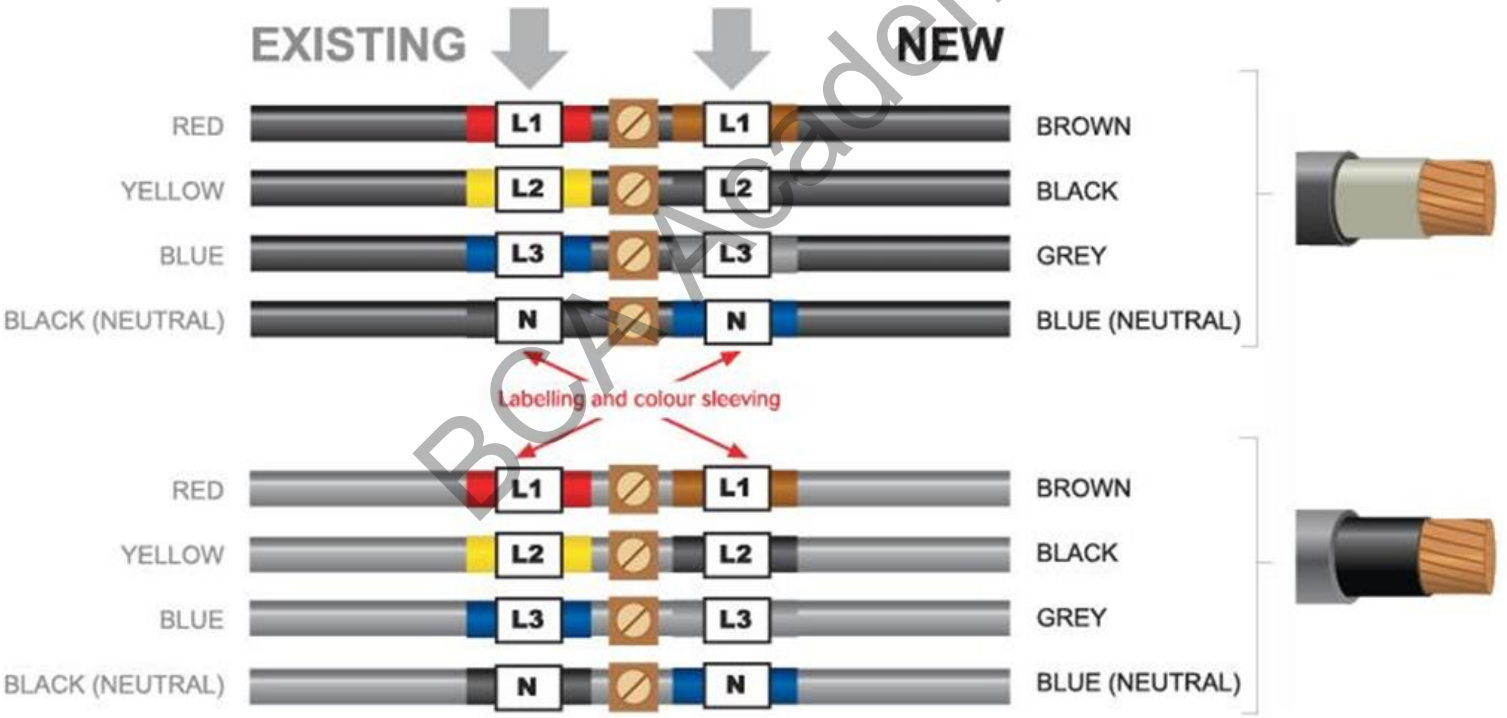


GUIDE TO COLOUR MARKING FOR THREE-PHASE CIRCUITS

In Singapore, the following two types of single-core cables are commonly used in electrical installations: i.e.

a. XLPE-insulated/pvc-sheathed (in black colour), and
b. pvc-insulated/pvc-sheathed (in grey colour).

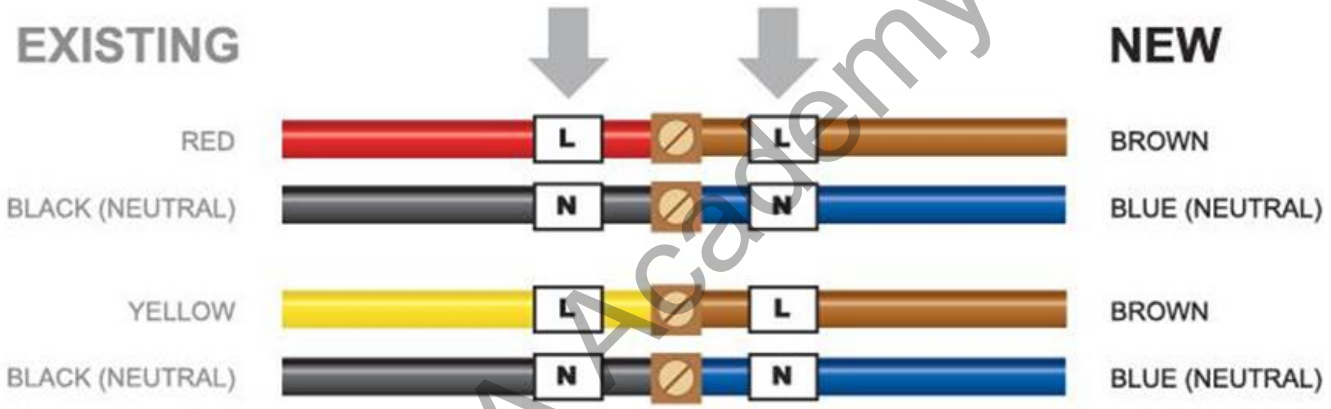
For identification of conductors, proper labelling and colour sleeving shall be provided at the interface as shown. A warning notice (see Figure 1 on page 10) shall also be displayed prominently at the appropriate distribution board that controls the circuit.



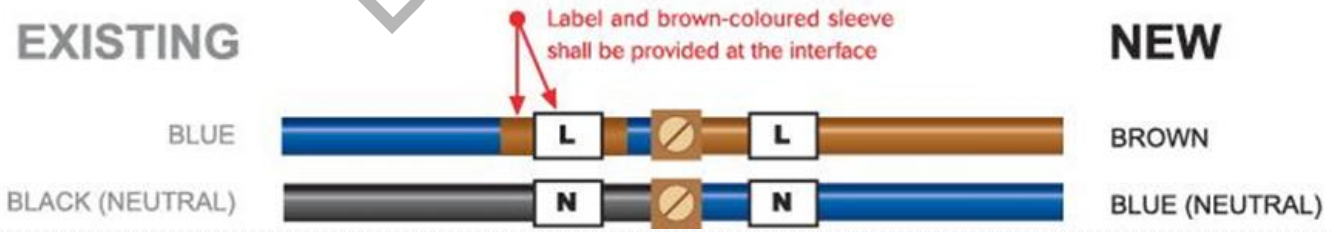
GUIDE TO COLOUR MARKING FOR SINGLE-PHASE CIRCUITS

Durable and legible markings shall be provided at the interface where the new and old versions of colour code for fixed electrical wiring exists.

A warning notice (see Figure 1 on page 10) shall also be displayed prominently at the appropriate distribution board that controls the circuit.



Where the existing blue-coloured cable (phase conductor) is to be connected to a new brown-coloured cable (phase conductor) of the same circuit, at the interface, the existing blue-coloured cable shall be labelled and provided with brown-coloured sleeve as shown to avoid confusion.



Inspection & Testing

Inspection

- Verification of compliance with Standards
- Correct selection and erection of Equipment

Testing

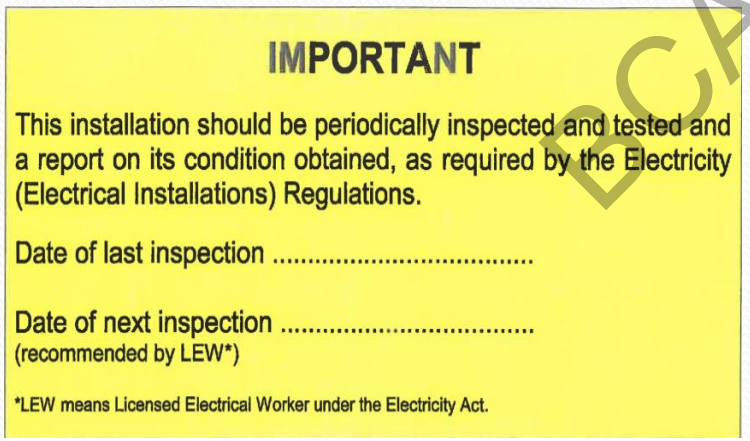
- Continuity of Protective Conductors including main and supplementary bonding conductors
- Insulation resistance
- Functional testing of RCD (using RCCB tester)
- Polarity
- Earth Electrode test

Circuit nominal voltage (V)	Test voltage d.c.(V)	Minimum insulation resistance (MΩ)
SELV and PELV	250	0.5
Up to and including 500 V with the exception of the above systems	500	1.0
Above 500 V	1000	1.0

Warning & Notices (514.10, 514.11 & 514.12)

Warning notice of maximum voltage be clearly visible where the presence of a voltage exceeding 230V to earth would not normally be expected.

Notice: Periodic Inspection & Testing of electrical installation



Warning notice: isolation

Where there are live parts are not capable of being isolated by a single device, the location of each disconnector (isolator) shall be indicated unless there is no possibility of confusion.

Caution Notice: Socket outlet not protected by RCD e.g. fire alarms, battery chargers and medical equipmet

Warning & Notices (Clause 514.12 .2 - 514.15)

Notices: **regular trip testing of RCD** - notice shall be fixed in a prominent position at or near the origin of the installation

> This installation, or part of it, is protected by a device which automatically switches off the supply if an earth fault develops. Test quarterly by pressing the button marked 'T' or 'Test'. The device should switch off the supply and should then be switched on to restore the supply. If the device does not switch off the supply when the button is pressed, seek expert advice.

Note: This method is applicable to ordinary person. Skilled person shall use RCCB tester.

Warning notices: **earthing and bonding connections**

- the point of connection of every earthing conductor to an earth electrode, and
- the point of connection of every bonding conductor to an extraneous-conductive-part, and
- the main earth terminal, where separate from main switchgear.

"Safety Electrical Connection – Do Not Remove"

Warning & Notices (Clause 514.12 .2 - 514.15)

Notice: Protection by (a) earth-free local equipotential bonding to 418.2, or (b) electrical separation to 418.3L

The protective bonding conductors associated with the electrical installation in this location SHALL NOT BE CONNECTED TO EARTH.

Equipment having exposed-conductive-parts connected to earth shall not be brought into this location.

Warning notice: non-standard cable colours

Notice to be fixed at or near the appropriate distribution board or feeder circuit

CAUTION

This installation has both old and new cable colour codes. Great care should be taken before undertaking extension, alteration or repair that all conductors are correctly identified.

Warning notice: Where alternative sources of supplies are provided, notice shall be placed:

- At the origin of the installation
- At the meter position, if remote from the origin
- At the consumer unit or distribution board to which the alternative or additional sources are connected
- At all points of isolation of all sources of supply.

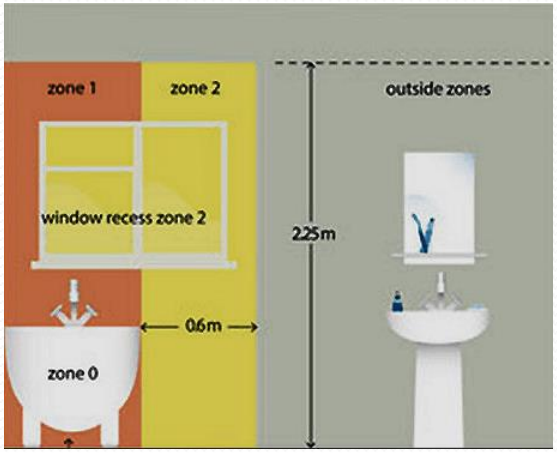
WARNING – MULTIPLE SUPPLIES

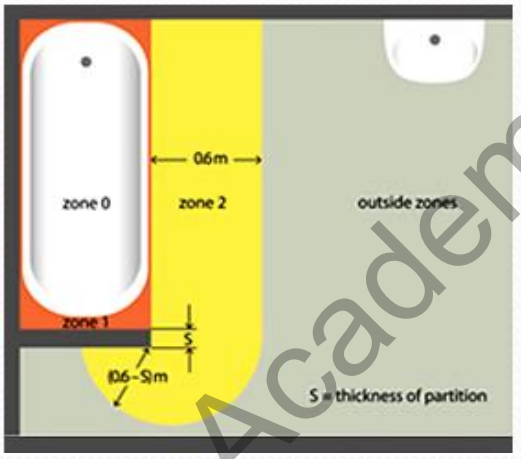
Isolate all electrical supplies before carrying out work.

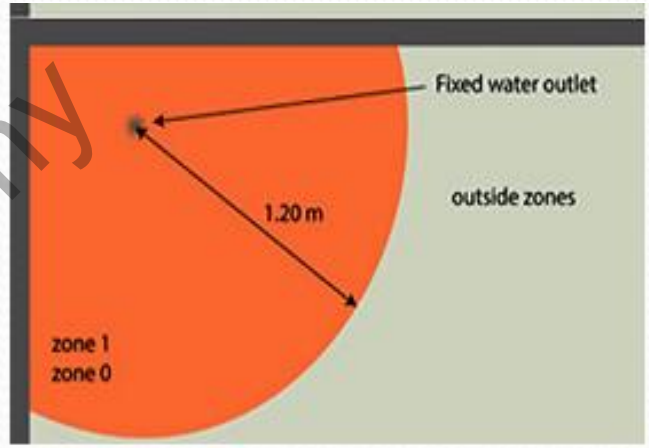
Isolate the mains supply at .....

Isolate the alternative supplies at .....

Special location: Bath or shower (Section 701L)





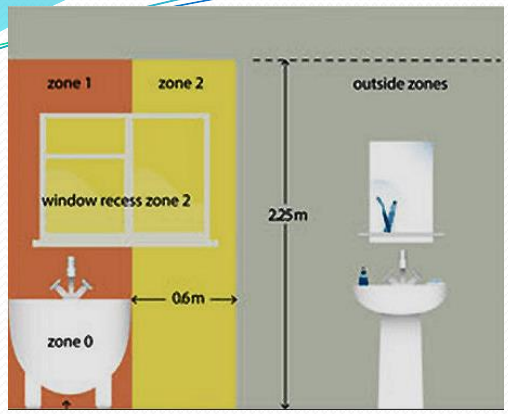


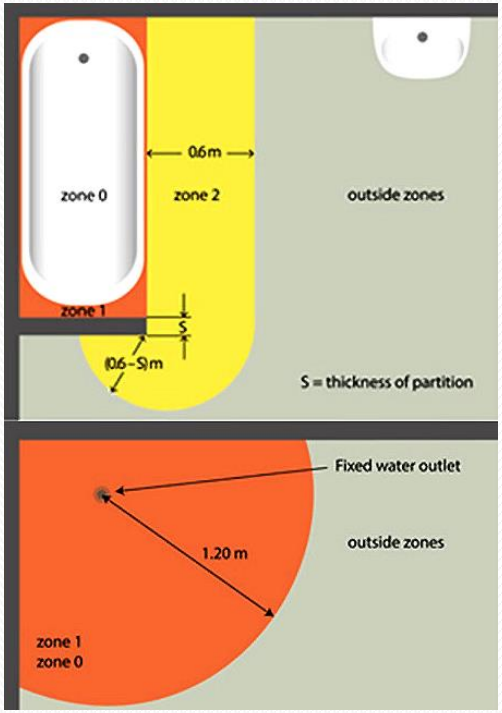
Zone 0
This zone requires a minimum of IPX7. This is the area within a bath tub.

Zone 1
This zone requires a minimum of IPX4. This is the area directly above a bath and within a shower cubicle.

Zone 2
Same as above, requires a minimum of IPX4. This is the area outside of the shower zone.

Special location: Bath or shower





- All extraneous-conductive-parts of the location are effectively connected to the protective equipotential bonding; and
- Basic protection for equipment are provided by:
  - Basic insulation (clause 416.1); or
  - Enclosures complying with 416.2

<u>In Zone 0</u>

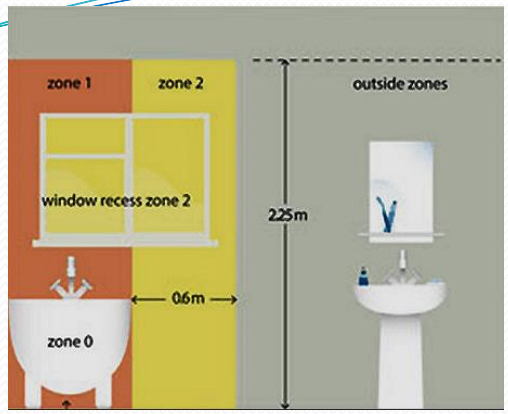
Equipment to be fixed and permanently connected, SELV voltage not exceeding 12Vac or 30V dc ripple free

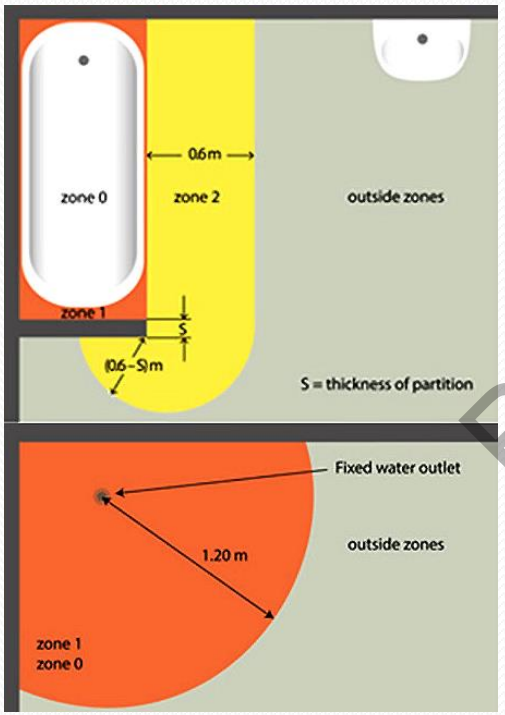
<u>In Zone 1</u>

Only the following fixed and permanently connected current-using equipment shall be installed, provided it is suitable for installation in Zone 1.

- Whirlpool units,
- Electric showers,
- Shower pumps
- Ventilation equipment,
- Towel rails
- Water heating appliances
- Equipment protected by SELV or PELV at a nominal voltage not exceeding 25 V a.c. rms or 60 Vdc ripple free, the safety source being installed outside Zones 0, 1 and 2

Special location: Bath or shower





<u>In Zone 2</u>

Switchgear, accessories incorporating switches or socket-outlets shall not be installed with the exception of:

(i) switches and socket-outlets of SELV circuits, the safety source being installed outside Zones 0, 1 and 2, and

(ii) shaver supply units complying with IEC 61558-2-5.

Note: Except for SELV socket-outlet, socket outlets are prohibited within a distance of 3 m horizontally from the boundary of zone 1

Special location: Bath or shower

Luminaires

Lamp holder within a distance of 2.5 m from the bath or shower cubicle shall be constructed of, or shrouded in, insulating materials.

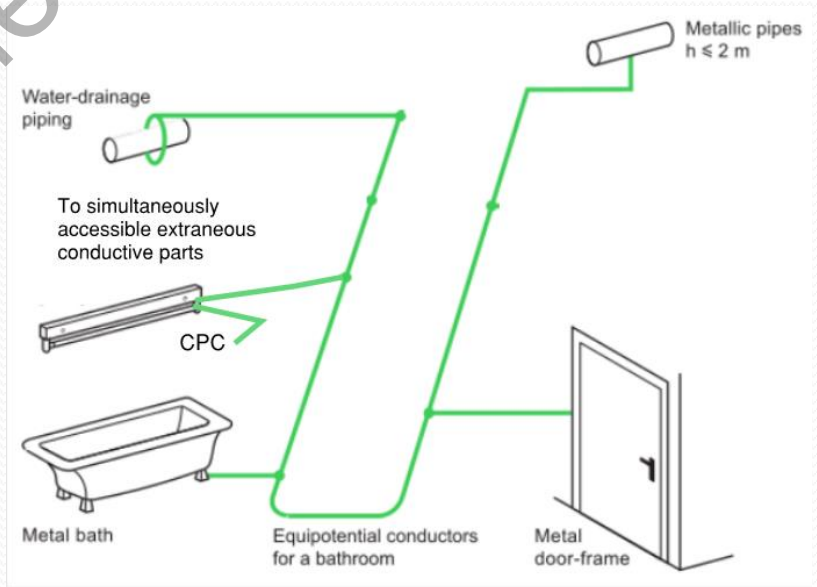
Bayonet lamp holders Type B22 shall be fitted with a protective shield or be totally enclosed luminaires

Shaver supply unit

- Except for SELV socket-outlets and shaver supply units complying with IEC 61558-2-5.

Supplementary equipotential bonding

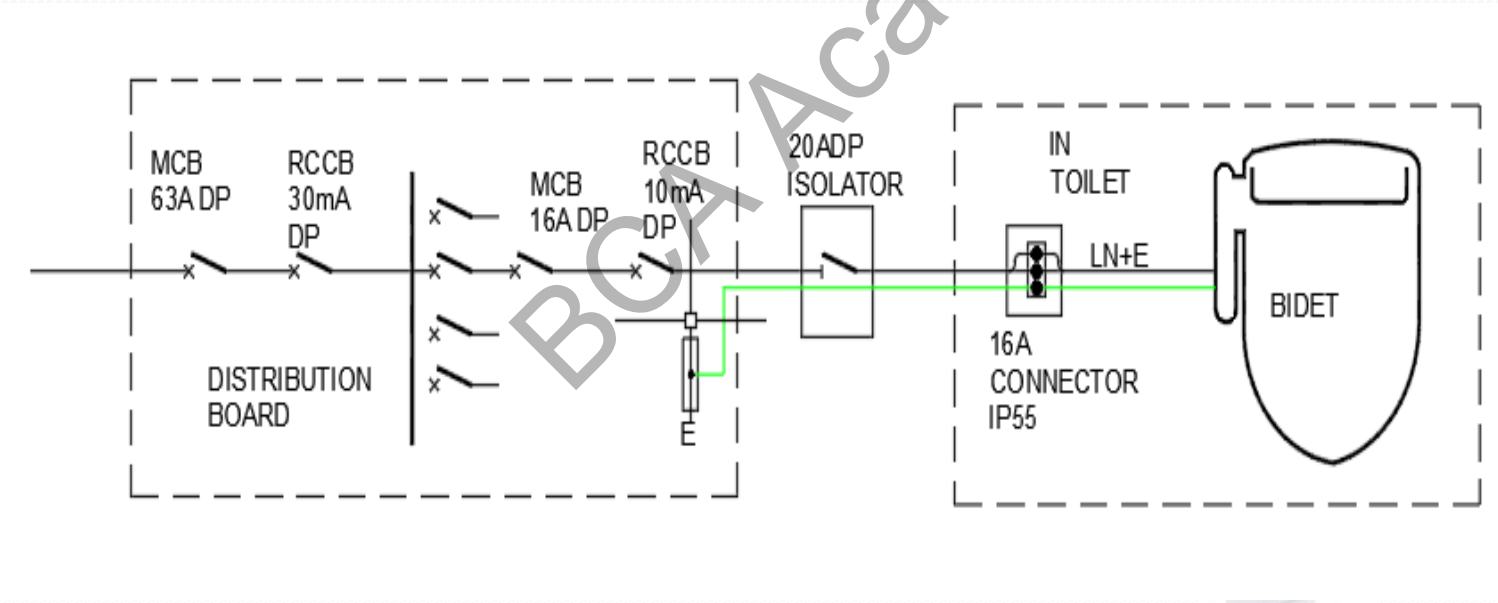
- Local Supplementary bonding to connected cpc of each circuit to accessible metal pipes and extraneous conductive parts within the room.



Special location: Bath or shower

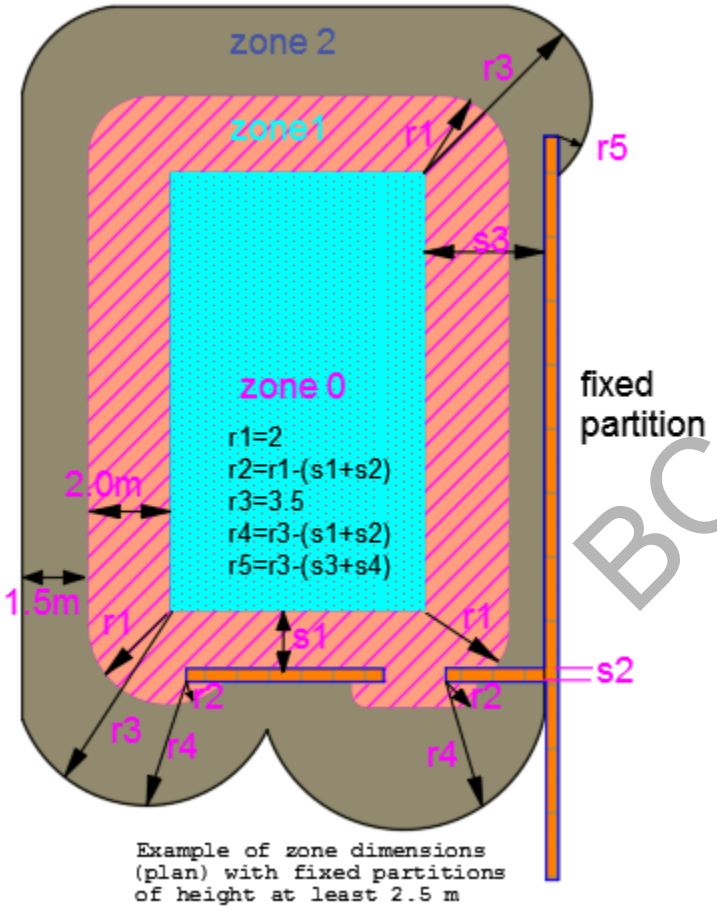
Electric Bidets

- Circuit for the electric bidet shall be protected by a 16 A MCB and a DP RCCB of voltage independent type complying to SS 97 with 10 mA rated residual operating current at the DB.
- NOTE: Electric bidets shall be approved by the Public Utilities Board



Special Location : Swimming Pools and other basins (Section 702)

Swimming Pools



Example of zone dimensions (plan) with fixed partitions of height at least 2.5 m

Classification of external influences

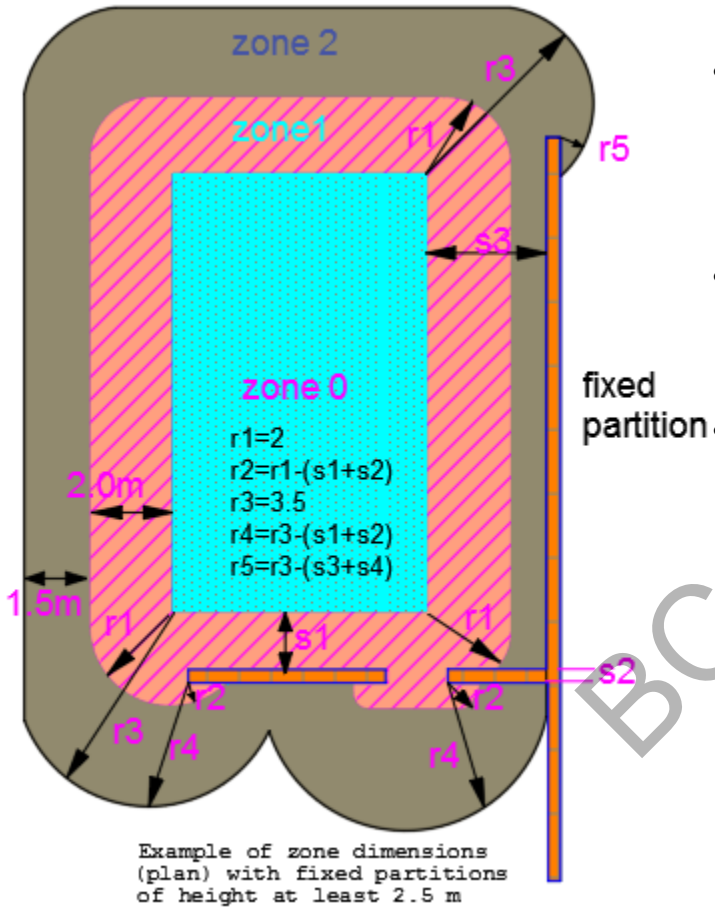
Electrical equipment must have at least the following degree of protection:

(i) Zone 0: IPX8

(ii) Zone 1: IPX4,IPX5 where water jets are likely to be used for cleaning purposes

(iii) Zone 2: IPX2 for indoor locations,
IPX4 for outdoor locations,
PX5 where water jets are likely to occur for cleaning purposes.

Special Location : Swimming Pools



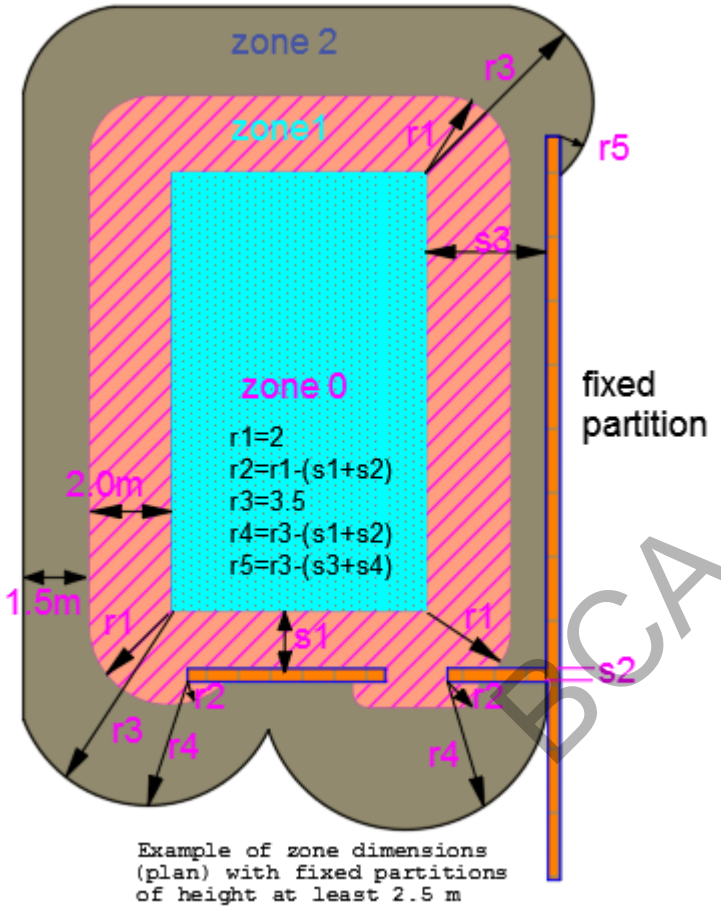
Example of zone dimensions (plan) with fixed partitions of height at least 2.5 m

Zone 0: SELV ≤ 12 V a.c.
Zone 1: SELV ≤ 25 V a.c.
Zone 2: SELV / 30 mA RCD

Protection for Zones 0 and 1

- Switchgear, controlgear, accessories and junction boxes are not to be installed (except for SELV junction boxes in zone 1)
- Only current-using equipment specifically designed for a swimming pool application may be installed.
- Socket-outlets may be installed in zone 1 (where it is not possible for them to be located outside zone 1) providing:
  - they are with non-conductive cover and more than 1.25 m horizontally from the border of zone 0 & at least 0.3m above the floor, and is protected by
  - SELV not exceeding 25 V a.c. and the source is outside Zone 0 and 1 or
  - protected by a 30mA RCD or by electrical separation with the safety isolating transformer installed outside of the zones.

Special Location : Swimming Pools



Example of zone dimensions (plan) with fixed partitions of height at least 2.5 m

Zone 2

- Equipment, socket-outlets, switches, and accessories are permitted in zone 2 but must be protected by electrical separation or SELV or a 30 mA RCD.
- Cables should preferably be installed in conduits made of insulating material.

Luminaires for swimming pools

Zone 0

- Only protection by **SELV** at a nominal voltage **not exceeding 12 V a.c. rms or 30 V ripple-free d.c.** is permitted
- The **source for SELV being installed outside zones 0, 1 and 2.**

Zone 1

- Only protection by **SELV** at a nominal voltage **not exceeding 25 V a.c. rms or 60 V ripple-free d.c. is permitted**,
- The **source for SELV being installed outside zones 0, 1 and 2.**

Exception

Where there is no zone 2, lighting equipment supplied by other than a SELV source at **12 V a.c. rms or 30 V ripple-free d.c. may be installed in zone 1 on a wall or on a ceiling,** provided that the circuit is :

- protected by **automatic disconnection** of the supply and
- **by an 30mA RCD and**
- **mounted at least 2 m above the lower limit of zone 1**
- **Luminaire with class II insulation.**

Submersible pumps for swimming pools

Submersible pumps for use in swimming pools when persons are in the pool to be of class III (SELV) with a rated voltage not exceeding 12 V and be at IPX8.

The instructions for class I portable pumps for cleaning and other maintenance of swimming pools shall include the substance of the following:

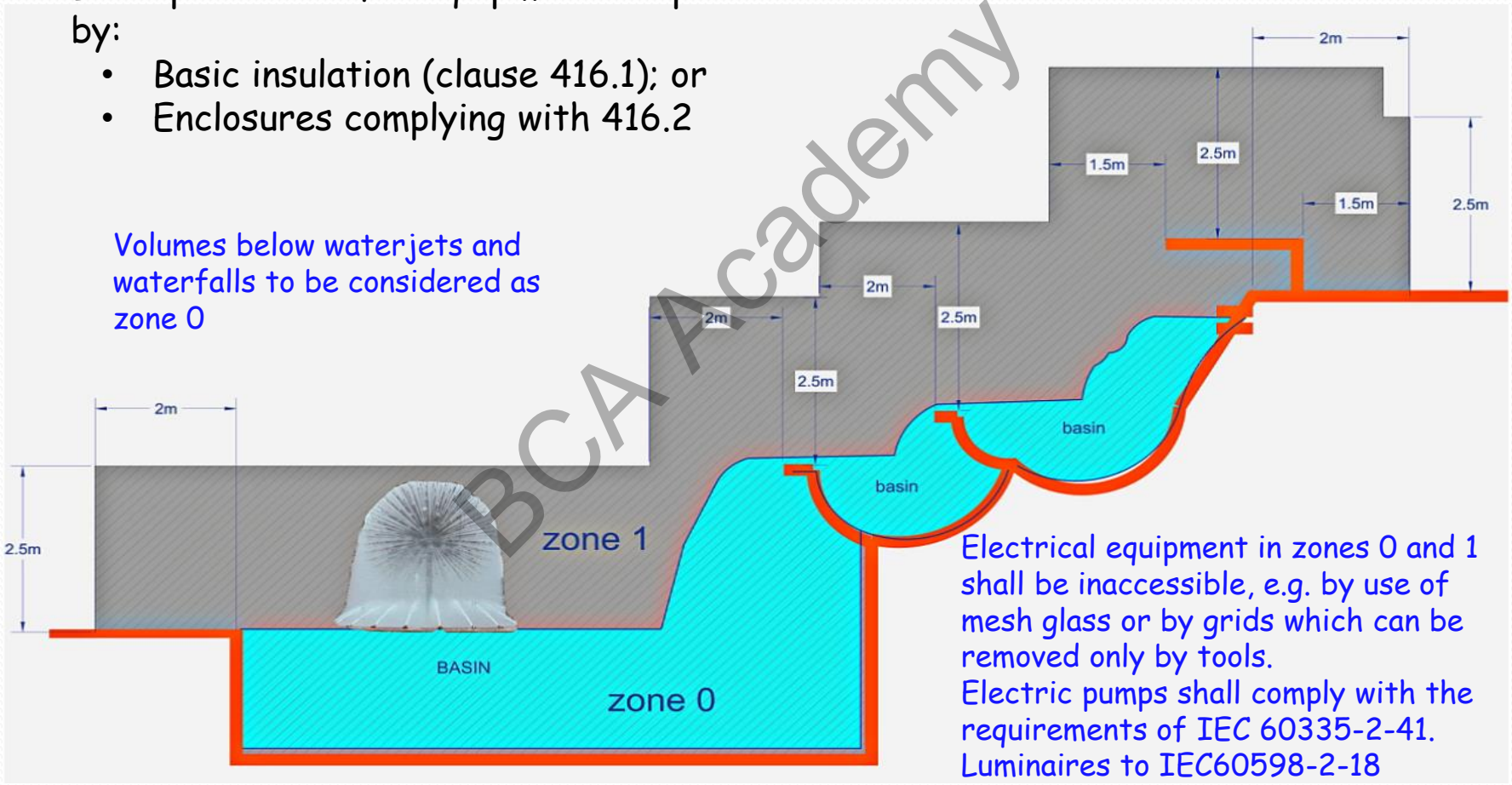
- the pump must not be used when people are in the water;
- the pump must be supplied through a residual current device (RCD) having a rated residual operating current not exceeding 30 mA.

The instructions for pumps marked with a temperature exceeding 35 °C shall state the maximum period of operation and the minimum rest period, unless the pump is intended for continuous operation at this temperature.

Special Location : Fountain

- All extraneous-conductive-parts of the location are effectively connected to the protective equipotential bonding; and
- Basic protection for equipment are provided by:
  - Basic insulation (clause 416.1); or
  - Enclosures complying with 416.2

Volumes below waterjets and waterfalls to be considered as zone 0



Electrical equipment in zones 0 and 1 shall be inaccessible, e.g. by use of mesh glass or by grids which can be removed only by tools.
Electric pumps shall comply with the requirements of IEC 60335-2-41.
Luminaires to IEC60598-2-18

Supply: SELV / 30 mA RCD

Special Location : Outdoor Lighting Installations (section 714)

Exclusion

Luminaires fixed to the outside of a building and supplied directly from the internal wiring of that building is excluded from this section

Requirements

- All live parts shall be protected by insulation or by barriers or enclosures. A door in street furniture, used for access to electrical equipment shall not be used as a barrier or an enclosure for basic protection.

- The access door to the electrical equipment shall be controlled by a key or a tool.

- The cross-sectional area of the earth conductor shall not less than that of the supply neutral conductor but not less than 6 mm^2, whichever is the smaller.

Special Location : Outdoor Lighting Installations (section 714)

- A maximum disconnection time of 5 s for all circuits feeding fixed equipment used in highway.
- Lighting in places such as telephone kiosks, bus shelters and signs shall be protected by 30 mA RCCB.
- A metallic structure (such as fence, grid etc.) which is in the proximity of but is not part of the outdoor lighting installation need not be connected to the main earth terminal.

Operating and maintenance gangway (Section 729)

Scope.
The particular requirements apply to the provision of:
(a) basic protection (e.g. barriers, enclosures); and
(b) access and gangways;

for skilled or instructed persons to perform installation, testing, operation, fault finding, repair and maintenance work, etc., taking into consideration requirements for emergency evacuation, emergency access and transport of equipment.

Accessibility of gangways

- Gangways longer than 10 m shall be accessible from both ends;
- Placement of equipment a minimum of 700 mm from all walls (see Fig 729.3)
- In the case of a fully withdrawn switchgear, minimum 700mm (see Fig 729.1) passing width is recommended for evacuation purpose.

Operating and maintenance gangway (Section 729)

Restricted access areas where basic protection is provided by barriers of enclosure

(i) Gangway width including between: • barriers or enclosures and switch handles or circuit-breakers in the most onerous position, and • barriers or enclosures or switch handles or circuit-breakers in the most onerous position and the wall	700mm
(ii) Gangway width of 700 mm between barriers or enclosures or other barriers or enclosures and the wall	700mm
(iii) Height of gangway to barrier or enclosure above floor	2000mm
(iv) Live parts placed out of reach	2500mm

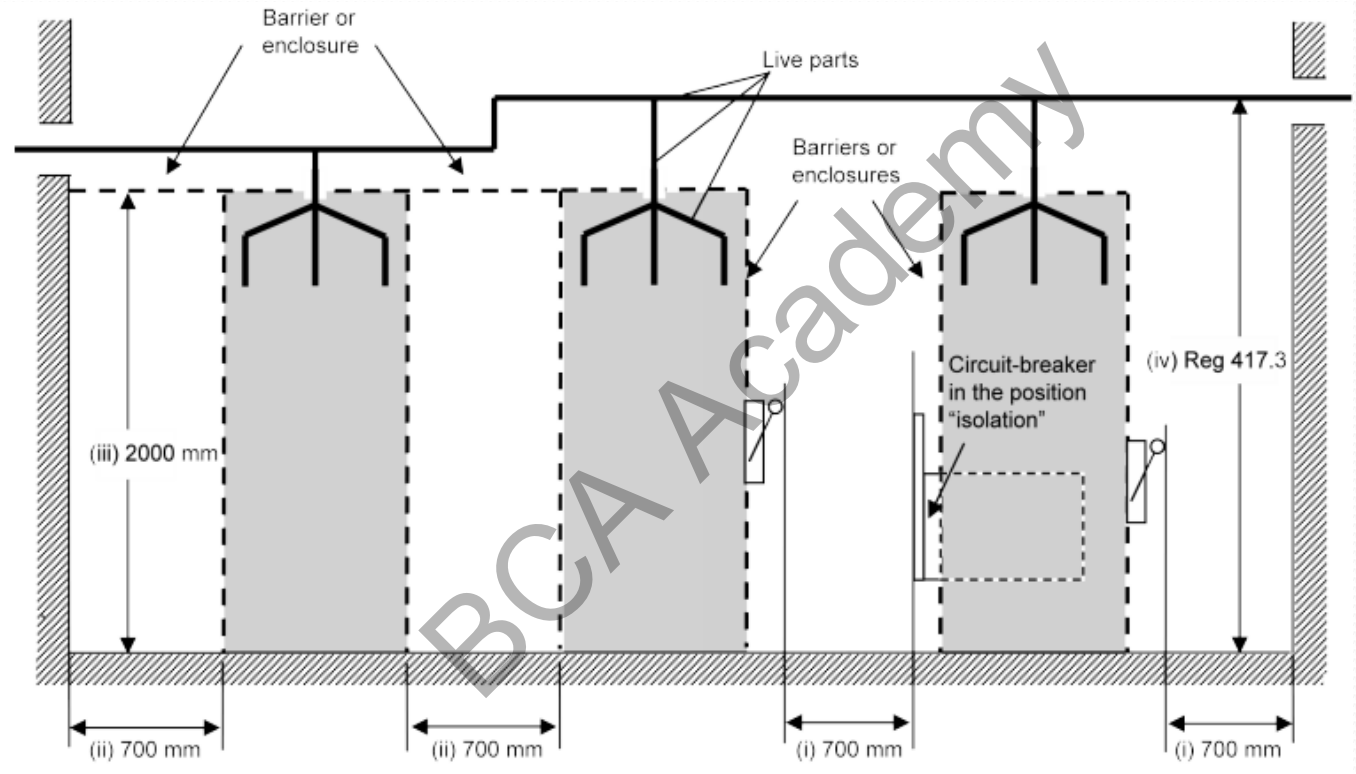


Figure 729.2 - Gangways in installations with protection by obstacles

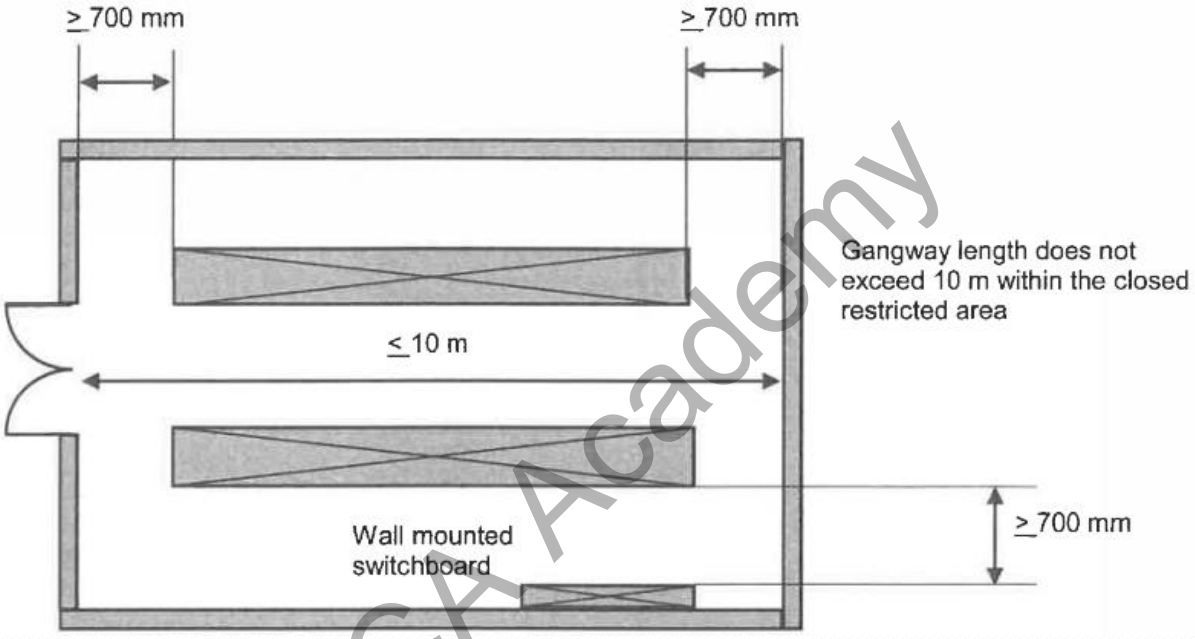


Figure 729.3 - Examples of positioning of doors in closed restricted access areas (a)

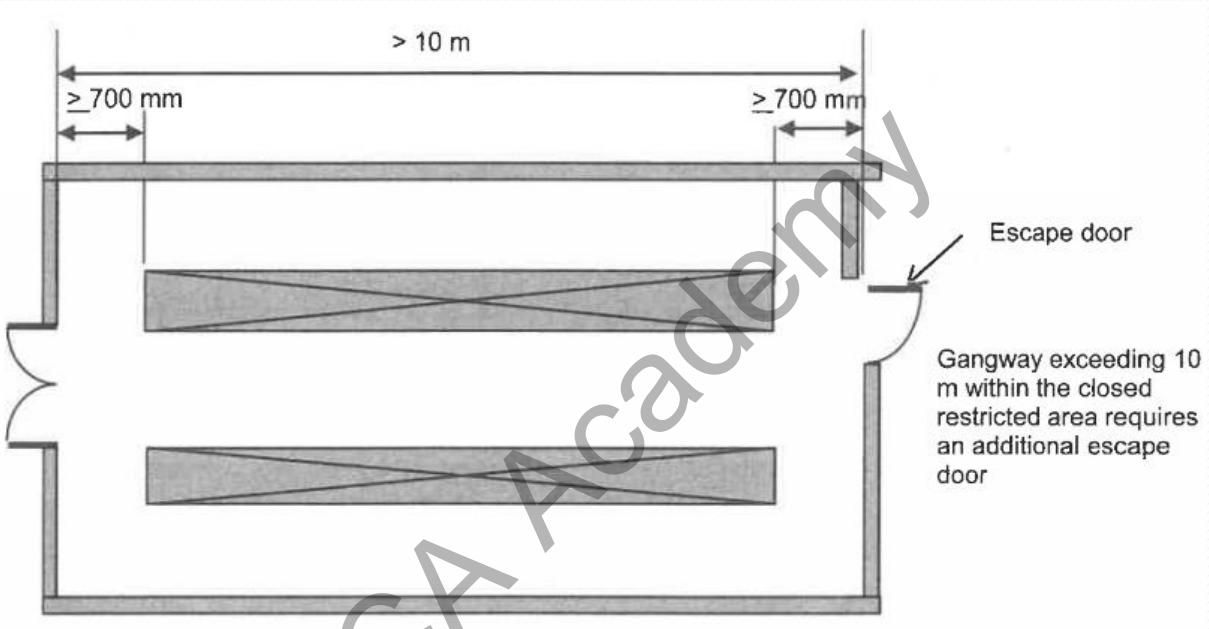


Figure 729.3 - Examples of positioning of doors in closed restricted access areas (b)

SINGAPORE STANDARD
SS 650 :2019

Code of practice for temporary electrical installations
PART 1 :
Construction and building sites

SINGAPORE STANDARD
SS 650 :2019

PART 2 :
Festive lighting, trade fairs,

mini-fairs and exhibition sites

SS650 Part 1

Scope

- Applies to temporary electrical installations for:
  1. New building construction;
  2. Repair, alteration, extension or demolition of buildings;
  3. Engineering construction;
  4. Earthworks;
  5. Other similar works.

Note: SS 650 Part 1 does not apply to installations in site offices, meeting room, show flats, dormitories, toilets, etc. located within construction sites.

SS 650 Part 2

Scope

Applies to electrical installations set up for the provision of electricity supply for:

- Trade-fairs or mini-fairs
- Exhibition;
- Amusement park;
- Decorative lighting in public place; or
- Any outdoor electrical installation set up for festive, religious or commercial event accessible to the public.

Note: SS650 Part 2 does not apply to:

- Decorative lighting within domestic premises
- Temporary installations receive supplies at voltage exceeding 1000V
- Discharge lighting installation operating at high voltage for decoration purpose
- Electrical equipment of machines

Types of supply

Public Supply System

1. Three-phase. 400V at 50Hz.
2. Single-phase. 230V at 50Hz.
3. Supply voltage from generating sets

Generating sets

- Unless otherwise approved by the skilled person responsible for the design and installation of supply installation, the output voltages shall be as follows:
  1. Three-phase. 400V at 50Hz.
  2. Single-phase. 230V at 50Hz.

Supply for Equipment

The following voltages shall not be exceeded:

(a)	Fixed plant, moveable plant fed via a trailing cable, installations in site buildings such as site offices, workshops, canteens and quarters, site lighting (Note. Not applicable to works performed underground)	400 V 230 V		3-phase, or Single-phase
(b)	Portable electric hand-held tools and portable hand-lamps, fixed flood lighting (Note. Not applicable to works performed underground)	230 V		Single-phase

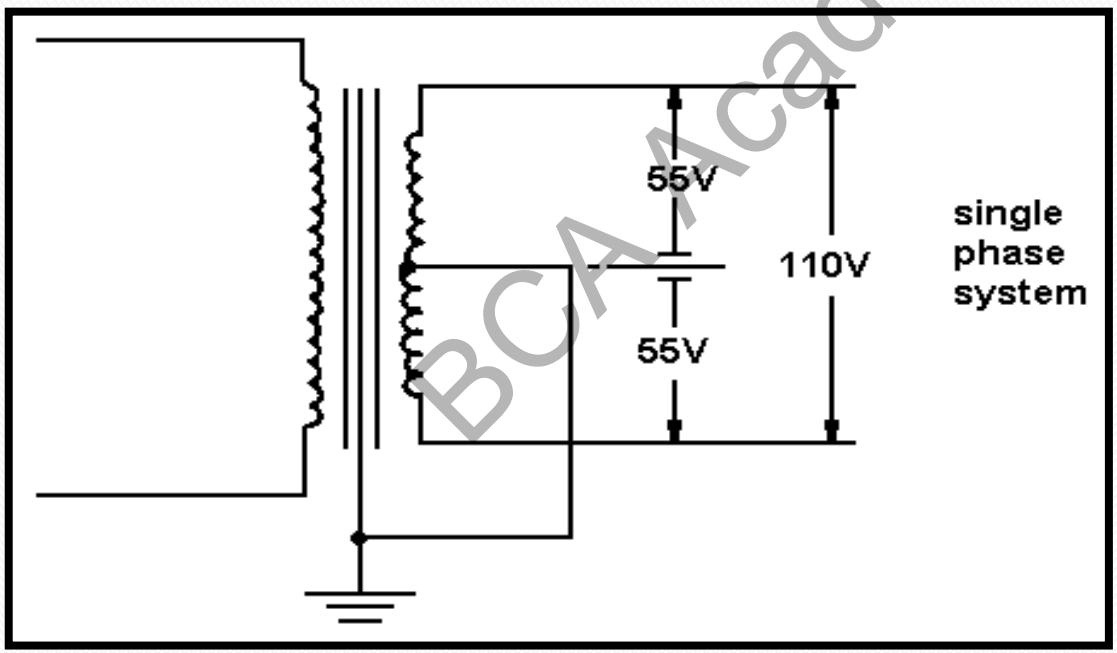
Supply for Equipment (cont'd)

The following voltages shall not be exceeded:

(c)	Portable electric hand-held tools and portable hand-lamps used underground such as any shaft, tunnel, caisson or cofferdam.	110V	Single-phase, centre point earthed
(d)	Portable electric hand-held tools and portable hand-lamps used in confined locations such as the insides of boilers, tanks or pipes, or in other similar situations.	25V 50V	Single-phase, SELV Single-phase, centre point earthed

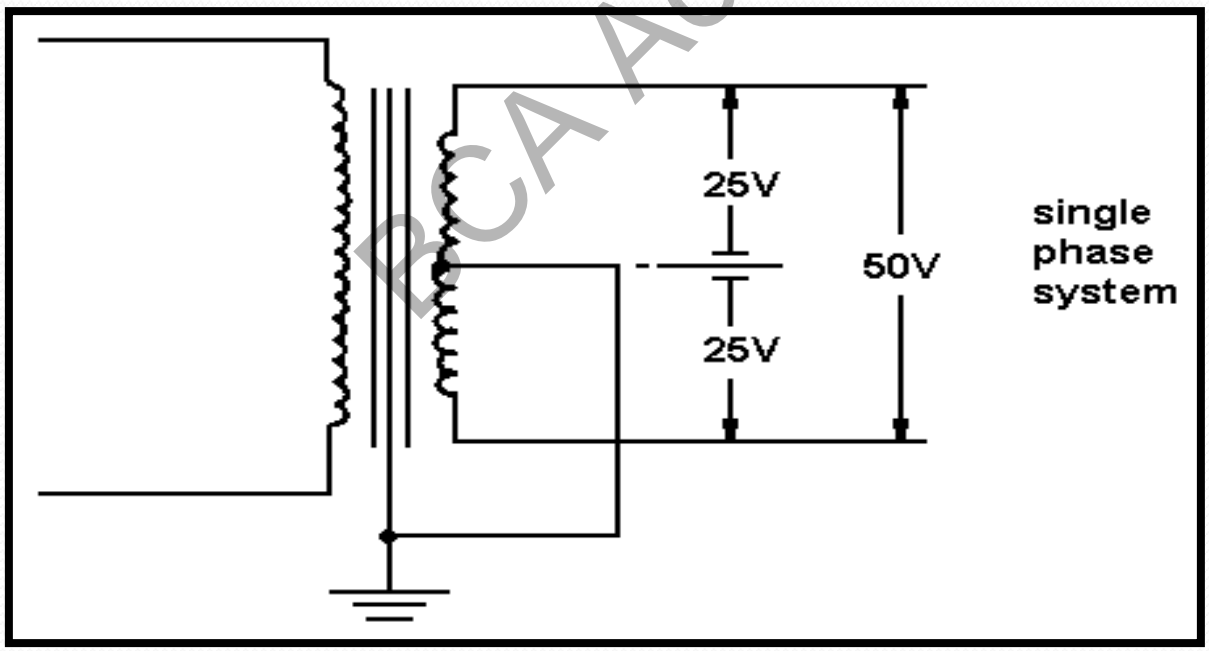
Reduced voltage

- 110V single phase. The supply shall be obtained from a double-wound transformer having the centre tap of the secondary winding earthed so that the nominal voltage to Earth is only 55V.

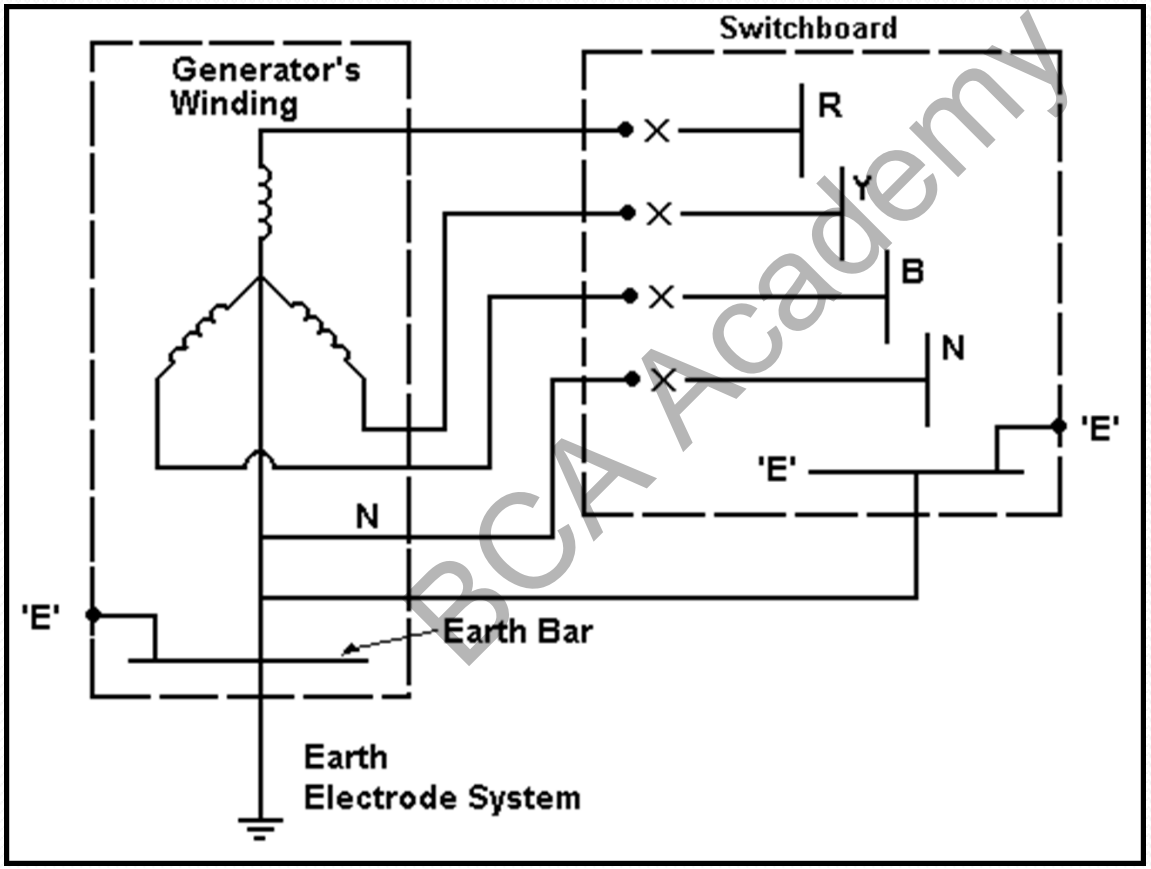


Extra low voltage

- 50V single phase. The supply shall be obtained from a double-wound transformer having the centre tap of the secondary winding earthed so that the nominal voltage to Earth is only 25V.



Earthing system of generator shall be TN-S system



Generating Set

Earthing arrangements of generating set

- Generating sets shall share a common TN-S earthing system

- The star point of a three-phase generator winding or the mid-point of a single-phase centre-tapped generator winding shall be solidly earthed

Earthing arrangements of generating set

- The following parts of the generating sets shall be bonded and connected effectively to the main earthing terminal:
  1. The engine frame;
  2. The generator frame;
  3. All exposed metal enclosure;
  4. Earth terminals of all socket-outlet (if any); and
  5. The main frame terminal (marked).

Protection for safety

- General
  - Means of isolation;
  - Means of overcurrent protection; and
  - Means of earth leakage protection

Control of supply

- Protection device for incoming supply
  - Incoming up to 300A - a circuit breaker with residual current device (RCD) shall be provided at the main switchboard
  - Incoming exceeding 300A - a circuit breaker incorporating overcurrent and earth fault protective devices shall be provided

Basic protection (protection against direct contact)

- One or more of the following basic protective measures shall be provided:
  1. Protection by insulation of live parts;
  2. Protection by a barrier or an enclosure,
  3. Protection by obstacles,
  4. Protection by placing out of reach.

  Note:
  The protective measures of obstacles and placing out of reach (item 3 & 4 above) are for application in installations that are controlled or supervised by skilled persons.

Fault protection (or protection against indirect contact) for low voltage system against electric shock

Protection by residual current device

- For TN-S system the following condition shall be fulfilled:

  $Z_s I_{\Delta n} \leq 25V$

  where:

  Z_s is the earth fault loop impedance in ohms

  $I_{\Delta n}$ is the rated residual operating current of the protective device

Fault protection (or protection against indirect contact) for low voltage system against electric shock

- For TT system

  Ra $I\Delta n$ ≤ 25V

  Where:
  Ra is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed conductive-part.
  $I\Delta n$ is the rated residual operating current of the protective device

Protection by Residual current device for final circuits

Current Rating of Final Circuit at 230V or 400V	Tripping Current & Tripping Time
• Not exceeding 63 A single-phase or three-phase	RCCB with tripping current not exceeding 30mA & trip within 0.1 sec
• Between 63A and 100A 3-phase or singe-phase	RCCB with tripping current not exceeding 300mA & trip within 0.1 sec
• Exceeding 100A 3-phase	RCD with tripping current not exceeding 500mA

Fault protection (or protection against indirect contact) for reduced voltage system against electric shock

Protection by residual current device

- For TN-S system the following condition shall be fulfilled:

  $Zs\ I\Delta n \leq 25V$

  where:

  Zs is the earth fault loop impedance in ohms

  $I\Delta n$ is the rated residual operating current of the protective device

Selection and erection of equipment

Wiring systems

- All underground cables shall be armoured.
- Outdoor cables shall be armoured and buried when there is a risk of mechanical damage; the armour of the cable shall NOT be relied on as a circuit protective conductor for the cable
- All cables which are likely to be moved in normal use shall be flexible cables.
- Trailing cables shall be of the armoured type having an over-sheath of heavy duty oil-resisting and flame-retardant compound.

Wiring systems

- Elevated cables shall be fully insulated having a sheath of PVC or an oil-resisting and flame-retardant or heat resisting sheath.
- Overhead cables exposed to sunlight shall have suitable non-metallic covering.
- Generally, use armoured cables or cables with adequate mechanical protection
- Except for rubber-insulated cables such as neoprene, ethylene propylene rubber, etc., non-metallic sheathed PVC insulated cables used for fixed wiring within the area covered by tents outdoor shall be installed in conduit or trunking

Switchgear and Controlgear Enclosure for Low-voltage Assembly

- The enclosure shall be robustly constructed and shall be so placed, installed and safeguarded:
  - To prevent damage by external influence
  - Shall be provided with adequate and safe means of access and working space for operation and maintenance purposes.
- Except for socket-outlet assembly, the enclosure for outdoor installation shall have:
  - A degree of protection of at least IP44
  - A roof so designed to prevent stagnation of water on its surface.

Devices for Isolation and Switching

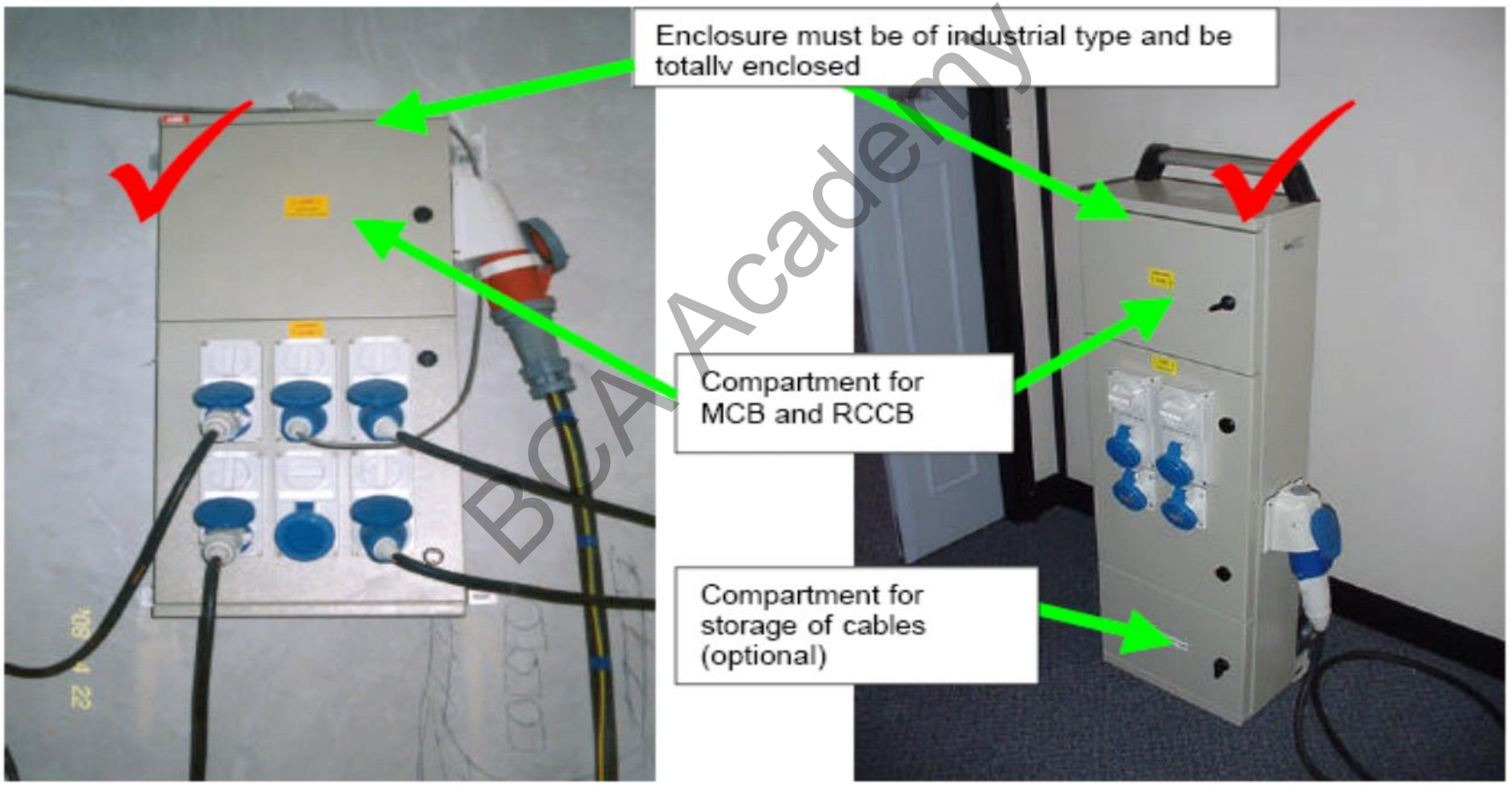
- A means for isolation and switching shall be provided and readily accessible at every switchboard or DB for disconnecting all phases, poles and the neutral
- Isolating switches or circuit breakers used for this purpose shall be suitable for securing in the OFF position.
- Every electrical installation of a booth, stand or amusement device shall have its own means of isolation and overcurrent protection, which shall be readily accessible

Socket-Outlet Assembly (SOA)


Industrial plug and socket-outlet

- Purpose Of The SOA
  - For connection of portable equipment at locations where fixed socket-outlets may not be available
- The intention is to reduce electrical hazard in temporary electrical installation

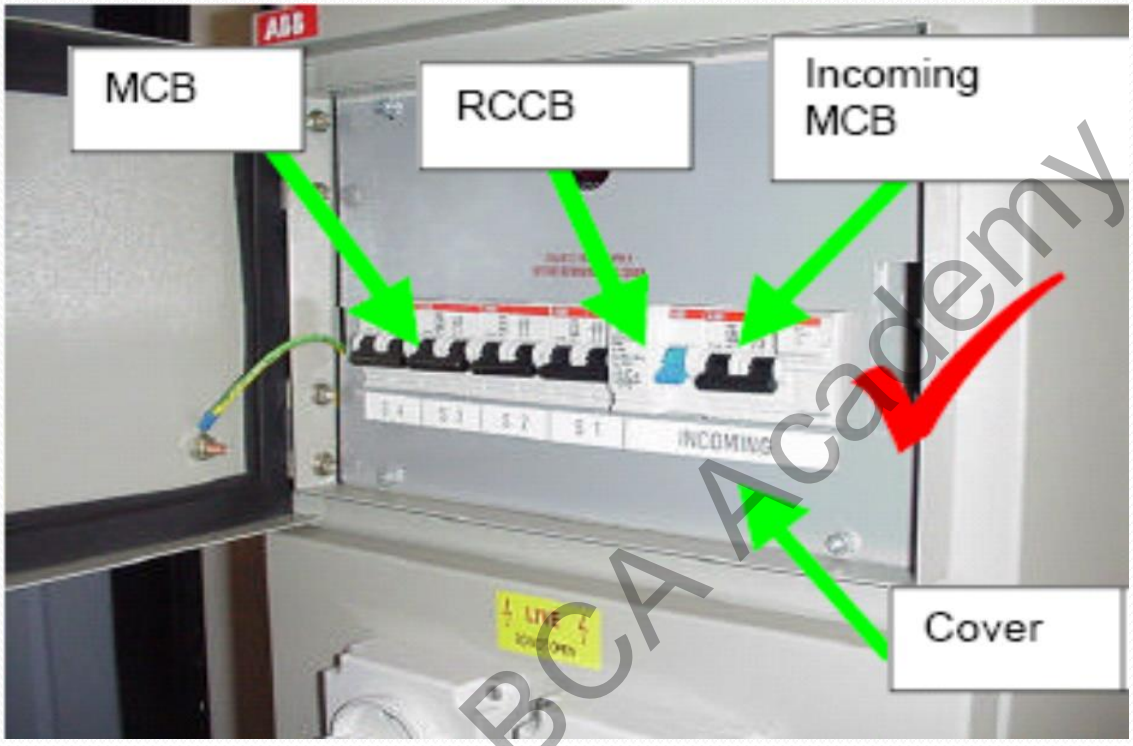
IMPORTANT POINTS TO NOTE WHEN USING SOA



Wall mounted SOA

Floor standing SOA

Construction of SOA



Enclosure : Totally enclosed with all live parts protected

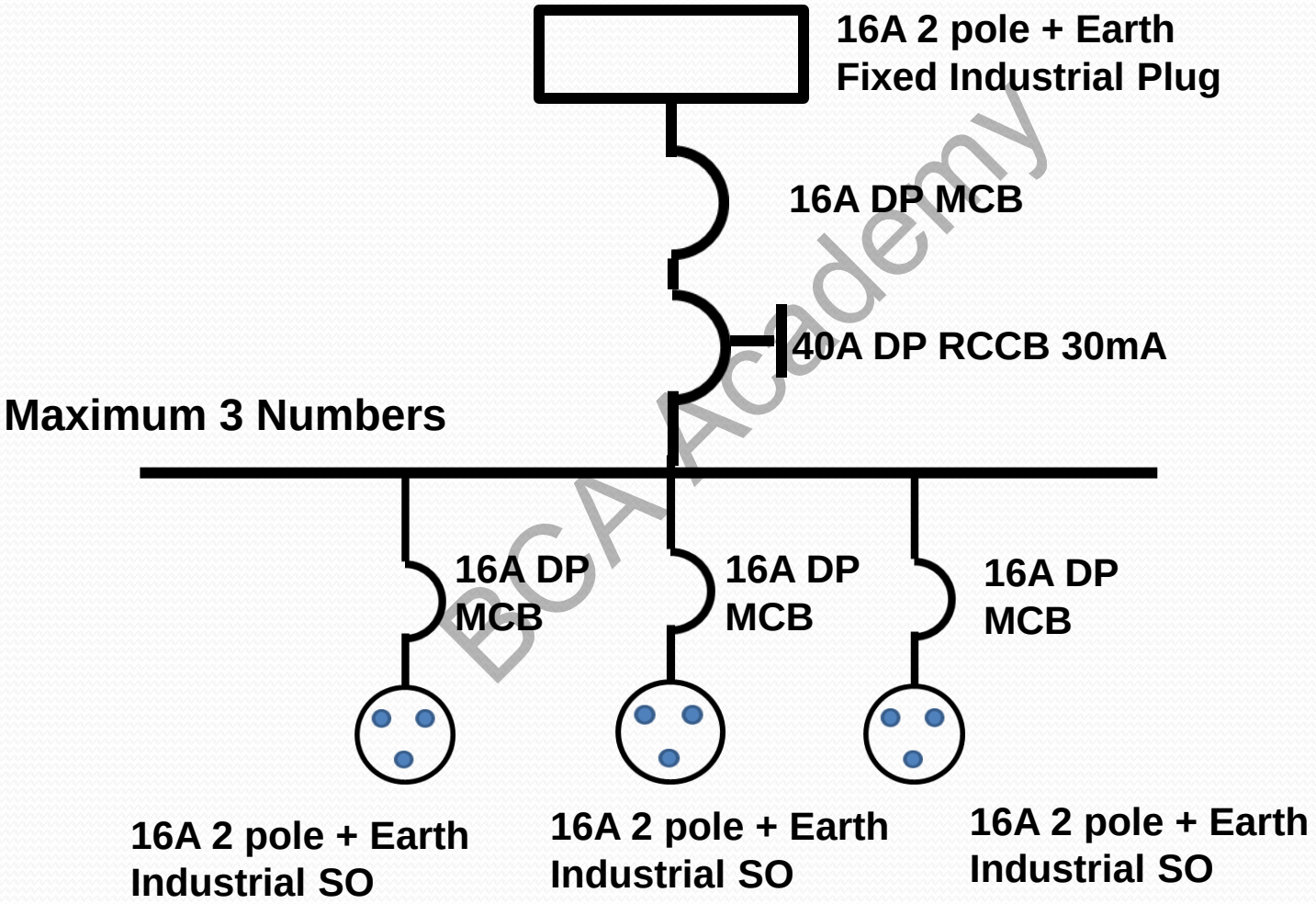
Circuit breakers: MCB & RCCB

Industrial plugs and socket-outlets

Colour Code for Industrial plugs, socket-outlets

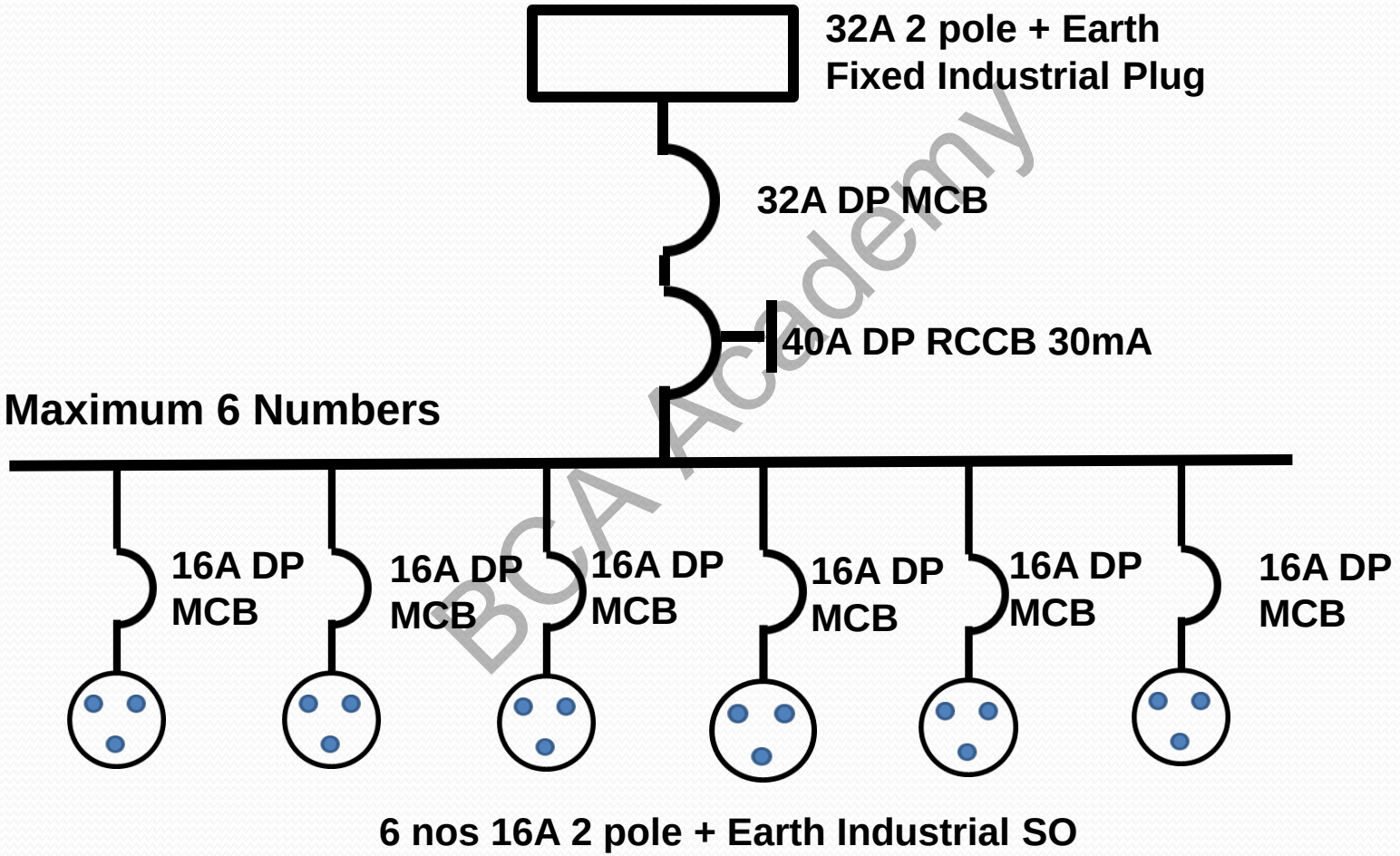
Operating Voltage (V)	Colour	examples
55	White	
110	Yellow	
230	Blue	
400	Red	

Single-phase Socket-outlet Assembly Fed from 16A Single-phase Source



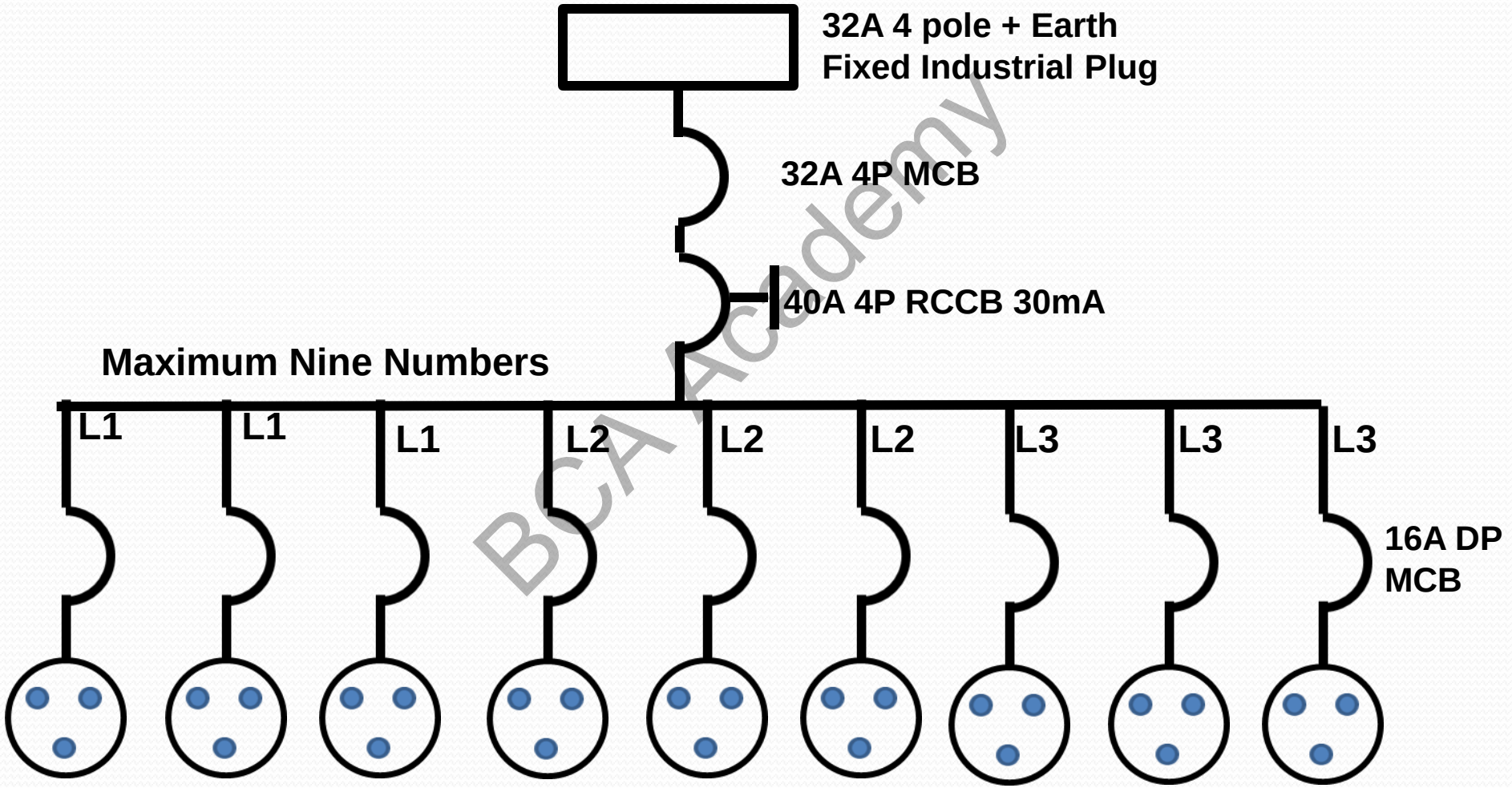
94

Single-phase Socket-outlet Assembly Fed from 32A Single-phase Source



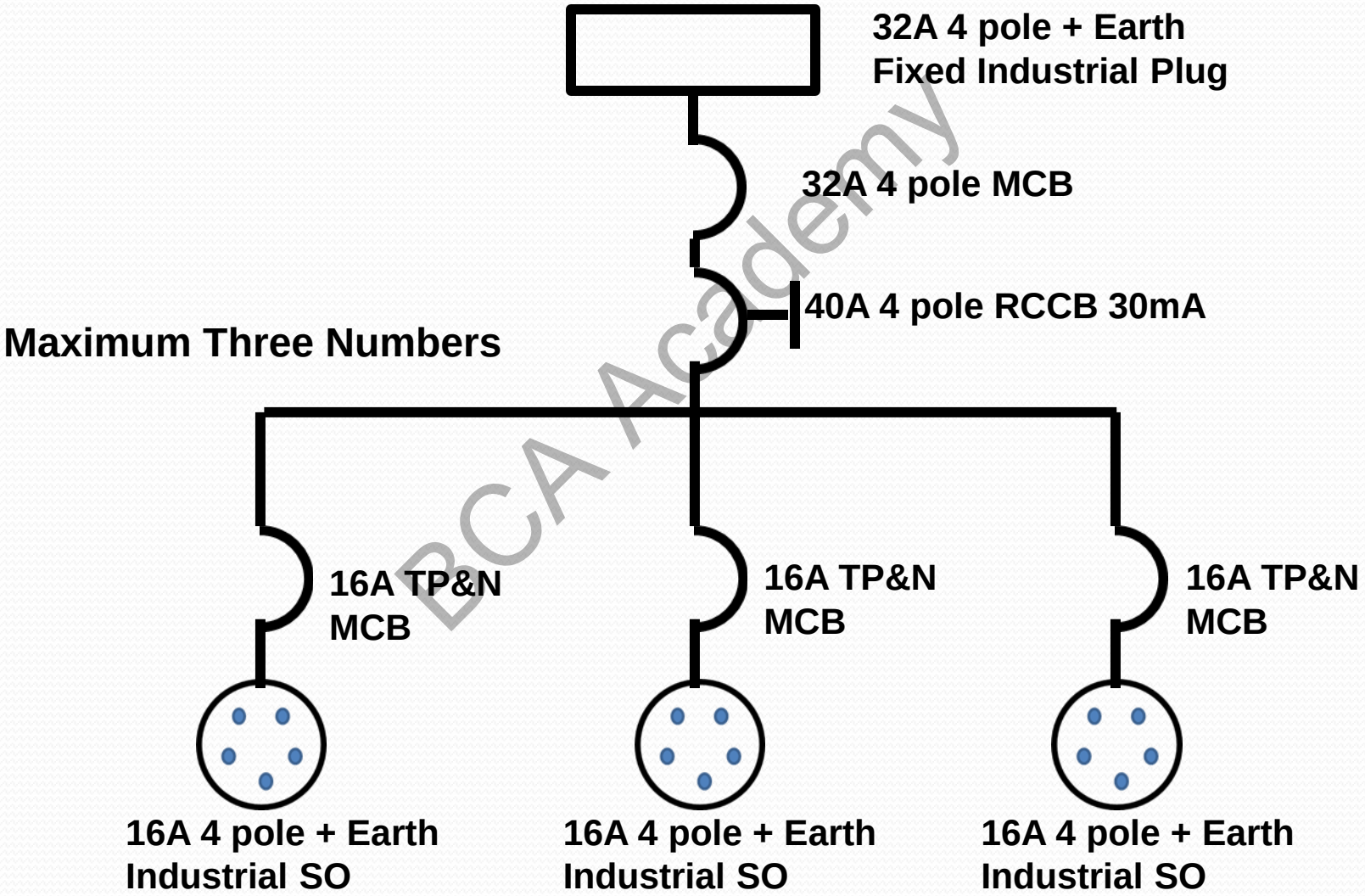
95

Single-phase Socket-outlet Assembly Fed from Three-phase Source

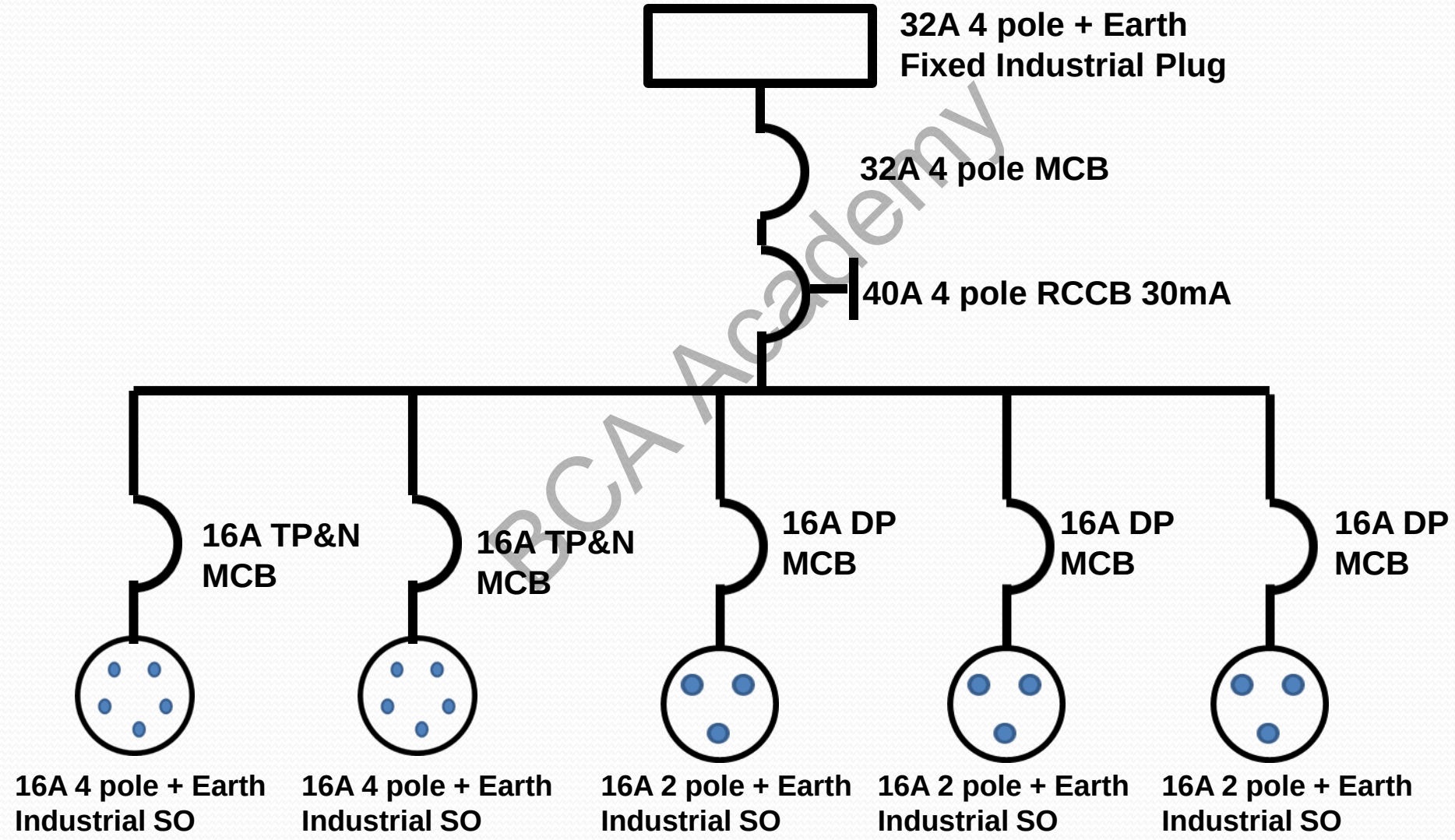


96

Three-phase Socket-outlet Assembly Fed from Three-phase Source



Three-phase and Single-phase Socket-Outlet Assembly



Earthing of Metal Structures – Fair sites

- All metallic tent structures within a fair or exhibition site
  - Shall be bonded effectively to the earthing system of the electrical installation.
  - Where decorative lighting is installed, all associated metallic-supporting structures shall also be bonded to the same earthing system.
  - Every item of equipment shall be selected and erected so as to comply with the general requirements stipulated in the Singapore Standards SS638

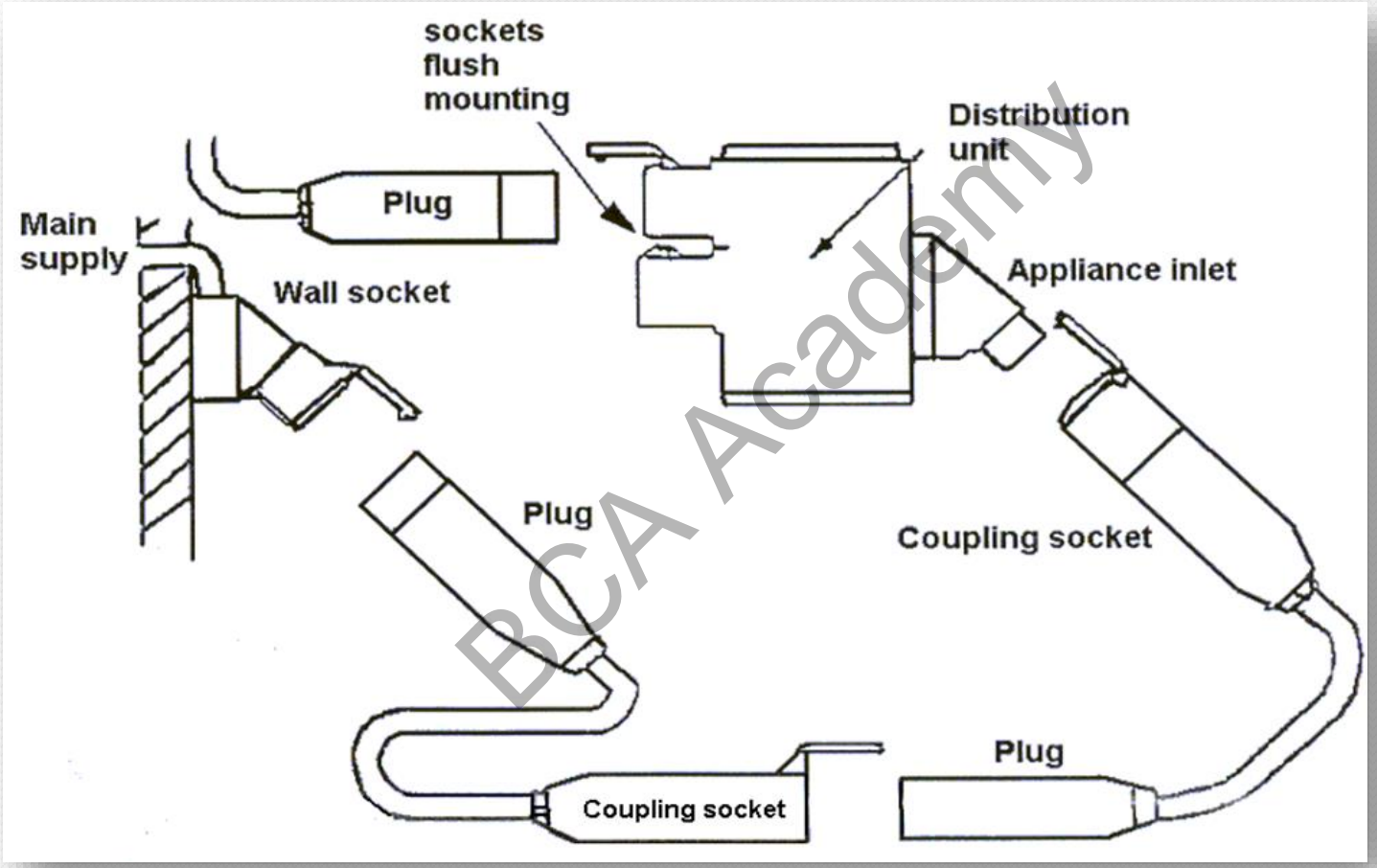
Wiring System – Fair Sites

- Installation of cables
  - Where appropriate, cables shall be of flexible construction.
  - Cables shall have a minimum voltage designation of 450/750 V,
  - Armoured cable shall be used where there is risk of mechanical damage.
  - The armour of the cable shall not be relied on as a circuit protective conductor for the cable.

Wiring System – Fair Sites

- The routes of cables buried in the ground shall be marked at suitable intervals.
- Buried cables shall be protected against mechanical damage.
- Cables shall not be run across public roads or walkways unless:
  - Adequate protection of the cables is provided against mechanical damage; and
  - Such installation will not cause any obstruction or pose any danger to the public.

Electrical Connections



Electrical Welding System

- **DC welding sets shall be used as far as practical to ensure safety**
- Where the use of A.C welding set is inevitable **for special welding works**, the following safety procedures **SHALL** be observed:

1. Every A.C. welding set must be equipped with a low voltage shock preventor which shall effectively reduce the open circuit secondary voltage to a safe level not exceeding 25 V

2. The low voltage shock preventor shall be of the built-in type and housed in a lockable weatherproof metal casing to prevent tampering

3. The workpiece should be connected to the return terminal of the welding set through a proper return conductor

Electrical Welding System

4. Every welding work involved A.C. welding sets is to be performed under **DIRECT SUPERVISION**, as far as practicable. **The supervisor and welder shall ensure that all safety precautions are observed at all times**

5. The low voltage preventor shall be inspected and tested by a competent person **once every 6 months**

General & Decorative Lighting

- General requirements

  Use LV (by 30 mA RCD) or

  SELV(25 V a.c. or 60 V ripple-free d.c.) if within reach of the public
- Suitable for the application environment
- Min. Ip44 (likely exposed to weather or water splashing) or
- In weatherproof enclosures

Installation of equipment

- Securely attached to structure or support
- Sited/guarded to prevent risk of injury/ignition of material (<2.5 m)
- Protected by barrier/enclosure (<2.5 m)

Discharge Lamp (230V/400 V A.C)

- Out of arm's reach or
- Adequately protected to reduce injury
- Fascia/back shall be non-ignitable
- Controlgear to be mounted on non-ignitable material
- Emergency switch be easily visible/accessible

Inspection, Testing and Maintenance

- Tested in accordance with Part 6 of SS638 before turn-on.
- Maintenance and periodic inspection by a skilled person in accordance with regulatory requirement (see below) and Chapter 62 (with reference to Chapter 61 where required).
- All temporary electrical installations in construction and building sites shall be inspected at least once a month.
- All temporary electrical installations in festive lighting, trade fares, mini-fairs and exhibition sites shall be inspected daily.
- Sign the checklist and hand it over to the operator of the electrical installation
- Rectify any defects found, or isolating or disconnecting the defective part(s) from electricity supply

Conclusion

- The design, installation and maintenance of electrical distribution systems are essential to the reliability of the plants and buildings, and the safety of the personnel in the buildings.
- Thorough understanding of the code of practice requirements and strict compliance to ensure electrical safety is our duty and responsibility.

END