BCA ACADEMY

Refresher Course for Licensed Electrical Workers (Technicians / Engineers) (33rd run)

School of Graduate Development and Management

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TOPIC 1: KEY HIGHLIGHTS IN ELECTRICITY ACT AND RELEVANT REGULATIONS

1 Changes in the Electricity Industry

1.1 Role of the Electricity Industry in Singapore

The electricity industry plays a significant role in the Singapore economy. With its history of rapid growth and expanding demand for domestic and commercial energy, Singapore is very reliant on an efficient and modern electricity system. The reliable supply of electricity, at a competitive price, influences the ability of Singapore industry to compete domestically and internationally, which in turn has a direct impact on the national economy.

1.2 Overview of Industry Reform Process

The electricity and piped gas industries in Singapore have traditionally been vertically integrated and Government-owned. The Public Utilities Board (PUB) was formed in May 1963 to undertake the supply of water, electricity and piped gas to the population of Singapore.

The first reform of the electricity industry was in 1995 when the Government corporatised the electricity undertakings of the PUB. The intention was to gradually introduce competition in electricity generation and retail so that Singapore would have an electricity market that allows market forces rather than central planning to drive investment, production and pricing decisions. Please see below for the milestone developments of the electricity industry.

1 October 1995

Corporatisation of electricity and piped gas operations of the Public Utilities Board to gradually introduce competition in the energy market.

1 April 1998

The Singapore Electricity Pool (SEP) was established to facilitate the trading of electricity between generation companies and the retail company in a competitive environment. The SEP was operated by PowerGrid Ltd as the Market Administrator.

11 March 2000

In March 2000, the Government decided to continue with further deregulation of the industry to obtain the benefits of full competition. The key restructuring initiatives includes:

- The separation at the ownership level of the contestable and non-contestable parts of the electricity industry;
- The establishment of a system operator and market operator;
- The establishment of a real-time wholesale market; and
- The liberalization of the retail market.

1 April 2001

The Energy Market Authority (EMA) was formed to promote competition and regulate the electricity and gas industries.

The Energy Market Company (EMC) took over the role of Market Administrator.

As the first step towards separating ownership of the contestable parts of the industry from the natural monopolies, Singapore Power Ltd fully divested its generation companies, PowerSenoko Ltd and PowerSeraya Ltd, to Temasek Holdings.

1.3 <u>The Key Players in the New Electricity Market (NEM)</u>

- *The regulator:* The EMA is the Regulator of the electricity sector and has the ultimate responsibility for ensuring that the NEM meets the needs of Singapore.

- *The market operator:* The EMC is the company that will operate and administer the wholesale market.

- *The power system operator:* The PSO, which is a division of EMA, is responsible for ensuring reliable supply of electricity to consumers and the secure operation of the power system. The PSO controls the dispatch of facilities in the wholesale market, coordinates outage and emergency planning and directs the operation of the Singapore high-voltage transmission system under the terms of an "operating agreement" with SP PowerAssets, the transmission licensee.

- *The transmission licensee:* SP PowerAssets owns and is responsible for the operation and maintenance of the transmission and distribution networks. To ensure a reliable and efficient transmission and distribution system, SP PowerAssets appointed SP PowerGrid to manage its business including the management of the transmission network and the operation of the distribution network.

- *Generation licensees:* All dispatchable generators above 1MW must be licensed by the EMA and are required to be registered with the EMC as market participants. Mandatory participation ensures that all generators of any significant size are subject to the market rules.

- *Market support services licensees:* MSSLs provide market support services such as meter reading and meter data management. They also facilitate access to the wholesale market for contestable consumers and retailers, and are responsible for supplying electricity to all non-contestable consumers. At the start of the NEM, the incumbent supplier, SP Services Ltd, will be the only MSSL, although others may enter the market at a later date.

- *Retail electricity licensees:* Retailers are permitted to sell electricity to contestable consumers. They may be market participant retailers (MPRs) and obtain electricity for this purpose by purchasing directly from the wholesale market (provided that they are licensed by the EMA to trade in the wholesale market and are registered with the EMC as market participants) or non-market participant retailers (NMPRs) and obtain supply through the MSSL.

- *Consumers:* Consumers are categorized as contestable and non-contestable, depending on their annual electricity usage. Contestable consumers may purchase electricity from a retailer, an MSSL or directly from the wholesale market as direct market participants (provided in the latter case that they are licensed by the EMA to trade in the wholesale market and are registered with the EMC as market participants). Non-contestable consumers are supplied with electricity by a MSSL.

2 Changes in the Legislative Landscape

2.1 Period before 1 December 2002

Regulation Division, EMA, enforced the following Acts & regulations in respect of consumers' electrical installations:

(a) The Public Utilities Act (Cap. 261)

- The Public Utilities (Electricity) Regulations 1997
- The Public Utilities (Electricity Supply) Regulations 1997
- The Public Utilities (Licence to Use or Operate Electrical or Supply Installations) Regulations 1997

(b) The Electrical Workers & Contractors Licensing Act (Cap. 89)

- The Electrical Workers & Contractors Licensing Regulations 1997

2.2 Period between 1 December 2002 & 1 January 2003

The following Act and regulations were repealed on 1 Dec 2002.

- The Electrical Workers & Contractors Licensing Act (Cap. 89)
- The Electrical Workers & Contractors Licensing Regulations 1997

The relevant part of the Electricity Act (Cap. 89A) and the Electricity (Electrical Workers) Regulations came into operation with effect from 1 December 2002.

All licensed electrical workers were informed of the changes through Circular RD/E01/2002 dated 30 November 2002.

2.3 Period after 1 January 2003

The New Electricity Market opened on 1 January 2003 and the consumers' electrical installations are now being regulated under the following Acts and regulations:

- Electricity Act (Cap. 89A)
- Electricity (Electrical Installations) Regulations

The Electricity (Electrical Installations) Regulations replaced the following regulations made under the Public Utilities Act (Cap. 261):

- The Public Utilities (Electricity) Regulations 1997;
- The Public Utilities (Electricity Supply) Regulations 1997; and
- The Public Utilities (Licence to Use or Operate Electrical or Supply Installations) Regulations 1997.

All licensed electrical workers were informed of the changes through Circular RD/E02/2002 dated 30 December 2002.

3 Key Highlights of the Electricity Act and Regulations

3.1 Operating Voltage Limits Specified in Electrical Engineer Licences

Regulation 5(3) of the Electricity (Electrical Workers) Regulations (the "Regulations") states that the holder of an electrical engineer's licence shall, subject to any condition imposed by the Authority under regulation 8(3) of the Regulations, be entitled to design, install, repair, maintain, operate, inspect, test and take full charge and responsibility for any electrical installation.

While the electrical engineer's licence does not specify any limit on the approved load of the electrical installations (in terms of kVA) which the holder of the electrical engineer's licence is entitled to design, install, repair, maintain, operate, inspect, test and take full charge and responsibility for, the holder of an electrical engineer's licence shall not design, install, repair, maintain, operate, inspect, test and take full charge and responsibility for an electrical installation where the operating voltage of such installation exceeds the voltage limit that is specified in the electrical engineer's licence. A Circular was issued on 16 Nov 2015 (see Appendix 1) to remind licensed electrical engineers (LEEs) to comply with the operating voltage limit specified in their respective licences.

Licensed electrical engineers (LEE) authorised up to 1kV may continue to submit applications for high voltage (22kV and above) electricity supply and substation plans to SP Services and SP PowerGrid.

3.2 Electrical Installation Licences for Contestable Consumers

A landlord with a master-sub metering arrangement can be contestable either under the En-Bloc Contestability Scheme (ECS) or Demand Aggregation Scheme (DAS). This is to enable the half-hourly consumption of the landlord as a contestable consumer to be determined for settlement at the wholesale electricity market.

Information on eligibilities for contestability can be found in the website below;

https://www.mypower.com.sg/FAQS/En-Bloc_Contestability_Scheme.html

Under the ECS, the landlord (i.e. the master-metered account holder) will be buying electricity for the entire premises on behalf of all sub-metered tenants at market prices contracted between the landlord and their chosen retailer. The landlord will need the consent of **all** the tenants to buy electricity on their behalf.

The landlord shall hold a valid electrical installation licence to cover the electrical installations of both the landlord and all his tenants in the entire building under the ECS. The LEW appointed by the landlord shall take charge of all the electrical installations in the entire building.

A landlord who is unable to obtain the consent of all the tenants may become contestable under the DAS. Under this scheme, the landlord can carve out part of his common services load and the load of one or more consenting tenants for contestability under a sub-metered account. The remaining tenants can continue to buy electricity from SPS at the regulated tariff, or from electricity retailers if they meet the contestability criteria.

The landlord in this case shall hold a valid electrical installation licence to cover all the electrical installations that have been aggregated under the contestable sub-metered account under the DAS. The remaining tenants shall continue to hold separate electrical installation licences.

3.3 Lifetime Validity of Electrical Worker Licence

An electrical worker licence issued or renewed on or after 1 August 2014 will be valid for the lifetime of the licence holder unless it is cancelled or suspended. A successful applicant of an electrical worker licence will be issued with a lifetime licence. Existing LEWs will have their licences converted to a lifetime licence when they renew their licences.

The current requirements for all LEWs to attend a prescribed refresher course once every 5 years shall remain unchanged. An LEW who is 65 years or older shall continue to obtain certification from a Registered Medical Practitioner (RMP) once every 3 years certifying him fit to carry out and supervise electrical works. Self-employed LEWs are required to fulfill their medisave liabilities with the CPFB. The LEWs are liable to have their licence suspended if they failed to meet any of the conditions. More information on the lifetime validity of electrical worker licence can be found in Appendix 3.

3.4 Responsibilities of Licensed Electrical Workers

Licensed electrical workers (LEWs) are responsible for the electrical works under their charge. They shall ensure that the electrical installations are properly maintained according to equipment manufacturers' recommendations and are safe for use. Before taking over an electrical installation for operation, an LEW shall inspect the electrical installation and review the past maintenance records to satisfy himself on the fitness of the electrical installation for safe

operation. Where applicable, he should advise the owner/user of the electrical installation to carry out necessary maintenance and/or rectification work. More information on the responsibilities of LEWs can be found in Appendix 4.

4 Submission of SLD and Inspection Reports

Regulation 28(4) of the Electricity (Electrical Installations) Regulations state that no electrical or supply installation licence or a renewal of such licence shall be granted by the Authority unless the licensed electrical worker has (d) submitted a schematic single-line wiring diagram of the installation to the Authority or, where the licensed electrical worker is unable to submit the diagram, a written undertaking in such form as may be provided by the Authority; and (e) given a written undertaking to the Authority to inspect the electrical or supply installation at such regular intervals as may be required by the Authority and after each inspection submit an inspection report to the Authority.

LEWs shall submit the single-line wiring diagram to the Authority promptly when applying for a new electrical installation licence or when renewing such licences. It is the of the LEW to monitor the due date closely and submit the single-line wiring diagram to the Authority prior to the due date.

5 Regulatory Actions against LEWs

Regulatory actions will be taken against LEWs who fail to carry out their duties properly. Common omission of duties include LEWs failing to carry out mandatory inspections of electrical installations (daily inspection for trade fairs, monthly inspection for construction worksites, six-monthly inspection for multi-tenanted buildings, etc) under their charge; LEWs failing to supervise electrical work carried out by non-licensed workers, etc. The Authority may, in addition to any penalty which may be imposed under the Regulations, notwithstanding that the electrical worker licence has been issued or renewed since the occurrence of the relevant event (i) cancel, refuse to renew or suspend the licence for such period as it thinks fit; or (ii) in its discretion, issue in place of the electrical worker licence, an electrical worker licence of another class.

Regulatory actions against licensed workers can be found in the website below;

https://elise.ema.gov.sg/elise/findworkerservlet?Operation=Get&Item=SL

APPENDIX 1

Circular No : RD/E02/2015
Date of Issue: 16 Nov 2015

To: All Licensed Electrical Engineers

Dear Sirs

CLARIFICATION OF OPERATING VOLTAGE LIMITS SPECIFIED IN ELECTRICAL ENGINEER LICENCES

Regulation 5(3) of the Electricity (Electrical Workers) Regulations (the "Regulations") states that the holder of an electrical engineer's licence shall, subject to any condition imposed by the Authority under regulation 8(3) of the Regulations, be entitled to design, install, repair, maintain, operate, inspect, test and take full charge and responsibility for any electrical installation.

2 We wish to clarify, in relation to regulation 5(3) of the Regulations, that the holder of an electrical engineer's licence shall not design, install, repair, maintain, operate, inspect, test and take full charge and responsibility for an electrical installation where the operating voltage of such installation exceeds the voltage limit that is specified in his electrical engineer's licence.

3 Licensed electrical engineers (LEEs) are reminded to comply with the operating voltage limit specifications stated in their respective electrical engineer's licences, as clarified in paragraph 2 above.

4 For any clarification, please contact our officers in Electricity Inspectorate Branch at telephone number 6835 8060 or email to EMA_RD_ELISE@ema.gov.sg .

APPENDIX 2
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Circular No : RD/E01/2015
Date of Issue: 26 Jan 2015

To: All Licensed Electrical Technicians & Engineers

Dear Sirs

ELECTRICAL INSTALLATION LICENCES FOR CONTESTABLE CONSUMERS

The landlord/MCST of a multi-tenanted building would have his electricity consumption measured by master-meters while his tenants' electricity consumption would be measured by the respective sub-meters.

En-Bloc Contestability Scheme

2 A landlord/MCST can become a contestable consumer and buy electricity en bloc from an electricity retailer of his choice for the entire building under the En-Bloc Contestability Scheme ("ECS").

3 Under the ECS, the landlord/MCST is required to obtain the consent of all the sub-metered tenants to buy electricity on their behalf, and the tenants must not hold separate individual electricity accounts with SP Services. If any tenant subsequently decides to opt out of the en bloc arrangement, the landlord/MCST and all the tenants will have to revert as non-contestable consumers and buy electricity from SP Services at the regulated tariff. For more information on ECS, you may visit MyPower portal at URL:

http://www.mypower.com.sg/documents/En-Bloc_guidelines.pdf

Demand Aggregation Scheme

4 A landlord/MCST who is unable to obtain the consent of all his sub-metered tenants to buy electricity on their behalf may become a contestable consumer under the Demand Aggregation Scheme ("DAS"). Under the DAS, the landlord/MCST shall configure his internal electrical reticulation system to aggregate part of the common services load and/or the load of the consenting tenants under a sub-metered account. He can then become a contestable consumer in respect of the sub-metered account. For more information on DAS, you may visit MyPower portal at URL:

http://www.mypower.com.sg/documents/DAS_guidelines.pdf

APPENDIX 2
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Electrical Installation Licence for landlord/MCST under ECS and DAS

5 The landlord/MCST shall hold a valid electrical installation licence to cover (a) the electrical installations of both the landlord/MCST and all his tenants in the entire building under the ECS, or (b) all the electrical installations that have been aggregated under the contestable sub-metered account under the DAS, as the case may be.

6 Upon the landlord/MCST becoming a contestable consumer, all the tenants under ECS or all the relevant tenants under DAS can choose to continue holding their existing valid electrical installation licences covering their respective electrical installations until their existing licences expire. Thereafter, the electrical installation licence of the landlord/MCST shall cover the electrical installations of such tenants. The licensed electrical worker engaged by the landlord/MCST under ECS or DAS shall make the necessary arrangements to take charge of the electrical installations of the tenants as stated above.

7 For any clarification on the electrical installation licensing requirements under the ECS or DAS, please contact our officers in Electricity Inspectorate Branch at telephone number 6835 8060 or email to EMA_RD_ELISE@ema.gov.sg

APPENDIX 3

Circular No : RD/E01/2014
Date of Issue : 1 Jul 2014

To: All Licensed Electrical Workers

Dear Sir/Madam

LIFETIME VALIDITY OF ELECTRICAL WORKER LICENCE

To make it more convenient and reduce cost to Licensed Electrical Workers (LEWs) on licence renewals, the Energy Market Authority (EMA) is pleased to announce that an electrical worker licence issued or renewed on or after 1 August 2014 will be valid for the lifetime of the licence holder unless it is cancelled or suspended. A successful applicant of an electrical worker licence will be issued with a lifetime licence. Existing LEWs will have their licences converted to a lifetime licence when they renew their licences.

2 The current requirements for all LEWs to attend a prescribed refresher course once every 5 years shall remain unchanged. An LEW who is 65 years or older shall continue to obtain certification from a Registered Medical Practitioner (RMP) once every 3 years certifying him/her fit to carry out and supervise electrical works. An LEW who fails to attend the prescribed refresher course or obtain certification from a RMP, if applicable, within the stipulated periods will have his licence suspended.

3 You will be informed separately to renew and convert your licence to a lifetime licence prior to the expiry of your current licence. Please ensure that you update any changes to your personal particulars including your residential address at the EMA ELISE website.

4 If you need any clarification, please contact us at Tel: 68358060, 63767582 or 63767532 or send your enquiry to ema_lw@ema.gov.sg.

APPENDIX 4

Circular No : RD/E02/2014
Date of Issue: 29 Dec 2014

To: All Licensed Electrical Workers

Dear Sirs

RESPONSIBILITIES OF LICENSED ELECTRICAL WORKERS

Licensed electrical workers (LEWs) are responsible for the electrical works under their charge. They shall ensure that the electrical installations are properly maintained according to equipment manufacturers' recommendations and are safe for use. Before taking over an electrical installation for operation, an LEW shall inspect the electrical installation and review the past maintenance records to satisfy himself on the fitness of the electrical installation for safe operation. Where applicable, he should advise the owner/user of the electrical installation to carry out necessary maintenance and/or rectification work.

2 LEWs are reminded to exercise due care and diligence in performing electrical works and taking charge of electrical installations. The Energy Market Authority will take enforcement actions against LEWs who are found to have failed in carrying out their duties with due care and diligence.

3 For any clarification, please contact our officers in Electricity Inspectorate Branch at telephone number 6835 8060 or email to EMA_RD_ELISE@ema.gov.sg .

TOPIC 2: OVERVIEW ON APPLICATION OF ELECTRICITY SUPPLY

1 Introduction

In mid 1988, an application form CS/1 was introduced to replace the time-honoured white and pink cards for electricity supply applications. This change saves time and confusion for our electrical workers who have to do the filling up on behalf of their clients. This form is now renamed as Appendix 1 and could be found in the handbook "how to apply for electricity connection".

Customers will still have to employ the appropriate grade of licensed electrical workers to make the application submission on their behalf.

On the application form, information on the type of application and development, the supply requirement, the licensed electrical worker responsible and details of proposed installation or extension are required to be furnished.

Depending on the type of application and premises, the procedure will vary in the details. But generally, it consists of these main steps:

a) Submission of consultation
b) Submission of application
c) Site assessment and preparation of service connection (for direct connection)
d) Payment for Service connection
e) Readiness of intake point
f) Project implementation
g) Turn-on of supply

All applications for connection must be submitted to Supply Application Section in SP Services Ltd. SP Services Ltd (SPSL), SP PowerAssets Ltd (SPPA) and SP PowerGrid Ltd (SPPG) are subsidiaries of Singapore Power Ltd. SPSL provides support services for the electricity market. It receives requests for electricity service connection; offers terms and conditions of service connection; arranges for service connection energisation/turn-on; and collects transmission charges, security deposits and charges for other services on behalf of SPPA. SPSL also bills customers for consumption. SPPA is the Transmission Licensee and owner of the transmission and distribution network. SPPG, the managing agent for and on behalf of SPPA, develops, operates and maintains the transmission and distribution facilities.

The supply of electricity and electrical installation practices are governed by the Electricity Act and its subsidiary legislation.

2 Connection Voltages and Supply Frequency

In Singapore, the customers' load installations are connected at the following voltages:

Transmission voltage of 66kV and 230kV
Distribution voltage consist of 230V, 400V, 6.6kV, 22kV (may vary within ± 6%)

The supply voltages are classified in the following categories:

- Low Tension (LT) refers to 230V, single-phase and 400V, 3-phase
- High Tension (HT) refers to 22kV and 6.6kV
- Extra-High Tension (EHT) refers to 66kV
- Ultra-High Tension (UHT) refers to 230kV

The following connection schemes are provided, according to customers' load requirements:

- 230V, 50 Hz, single-phase, up to a maximum of 23kVA, 100A
- 400V, 50 Hz, 3-phase, 4-wire.
- 22kV, 50 Hz, 3-phase, 3-wire for a Contracted Capacity of:
- between 1,700 kW and 12,750kW for 2 HT 22kV services
- between 12,751kW and 25,500kW for 4 HT 22kV services.
- 66kV, 50 Hz, 3-phase, 3-wire for connection with minimum Contracted Capacity of 25,500 kW.
- 230kV, 50 Hz, 3-phase, 3-wire for connection with minimum Contracted Capacity of 85,000 kW.

Where the customer requires a connection voltage and/or frequencies that differ from those specified above, the customer is required to provide, install and maintain the necessary transformation equipment.

3 Distribution Connection

Each premises can have only one customer's intake connection point. For modification of connection (such as upgrading of the load requirement) to existing premises, the customer is required to amalgamate the existing service connection into one intake.

Submission of Consultation

For a development in the initial planning stage, the customer is advised to seek consultation with SPPG to ascertain SPPA's requirements for a new or modified connection to the transmission system. The LEW is required to submit the Consultation Form, together with a site/location plan to SPPG.

After receipt of the submission for consultation, SPPG will send a reply stating the approved load and other technical requirements, such as the provision of substation requirements necessary for the load connection to the transmission system.

Submission of Application

SPSL serves as a one-stop customer service centre. It receives all application forms on behalf of SPPG and responds to all applications made by the Licensed Electrical Worker (LEW), who acts as the customer's agent for connection to the transmission system.

Customers applying for their installations to be connected to SPPA's transmission system must submit their applications through their LEWs. Every application must be accompanied by all supporting documentation requested by SPSL. The Application Form together with a copy of the site/location plan, must be submitted to SPSL by the LEW for new or modified connections of new or existing premises to the transmission system.

Processing of Application

Generally, SPSL responds to applications within 10 business days.

The responses are made according to the following customer categories:

Direct connection

Direct service connection from SPPA's LT network to the customer's installation is available for a small load requirement not exceeding 280kVA (400A). However, the provision of a direct service connection is dependent on the available network capacity in the vicinity. If there is insufficient capacity, the customer is required to provide a substation for the connection.

For a larger load requirement exceeding 280kVA (400A), the customer has to provide a substation for SPPA to install necessary equipment to cater for the load.

Provision of Substation

When an application for load connection necessitates the provision of a substation, a site must be provided and a substation constructed by the customer at its own cost.

The customer can either choose his substation to be a dedicated or non-dedicated one. If the customer opts for a dedicated substation, he has to inform SPPG when he applies for connection. Otherwise, it shall be assumed that the substation would be non-dedicated.

The customer is advised to site the substation at an inconspicuous location, away from the main entrance of the development and major public roads. The customer is also encouraged to harmonise, blend and integrate the substation with its development.

SPPG's officers and vehicles will have full and unrestricted access to the substation.

4 Type of Premises

Multi-Metered Premises

A multi-metered premises is one where the landlord/MCST (i.e. a master-metered consumer or directly connected consumer) receives bulk intake service connection from SPPA, and transforms/reticulates the supply to all the tenants (i.e. sub-metered consumers) within the premises. Any application for new or modified connection (including upgrading) for the bulk intake to the multi-metered premises must be made by the landlord through its LEW.

A master-metered consumer means a consumer that is responsible for the common usage of a master-metered installation, which is connected to the transmission system.

A master-metered installation means an installation in which supply is received by a master-metered consumer and sub-metered consumers

A sub-metered consumer means a consumer, other than a master-metered consumer, that receives supply in a master-metered installation via the electrical system owned by a master-metered consumer.

The landlord/MSCT or HDB, in the case of HDB premises, must ensure that the total applied load requirement for service connections to the multi-metered premises meet the total existing and future load requirements for all tenants. All tenants applying for any upgrading of load must do so through their master-metered consumer. In this regard, the master-metered consumer must approve the load of all tenants within the premises.

If the landlord's existing approved load is insufficient to cater for the tenants' load requirement, the landlord, as a master-metered consumer, must submit an application to SPSL for modification (upgrading) of service connection to the existing premises. In this case, the existing service cables are amalgamated with the new intake. Hence, there will not be separate direct connections to the tenants of such premises.

Premises in Private Housing, Industrial Estates, Commercial Developments Requiring Provision of Low Tension (LT) Distribution Network

For connection to premises where several parcels of land are to be sold or leased individually, one or more substations must be provided by the developer. Where the individual parcels of land are to be sold prior to development of these substations, details of the substation requirements and approved load must be included in the sales agreement by the future land parcel's owner or lessee.

The developer must provide the development's total load requirement and include the breakdown of the individual premises' load requirement (as specified in the sales agreement) and the communal load requirement, if applicable.

In the case of landed housing estate development, the LEW must liaise with National Parks Board for the siting of overground distribution boxes on turfed areas. SPPA will provide and install the LT distribution network and service connection cables for the development.

Premises Involving Temporary Connection With Provision Of Substation

Special terms and conditions apply in such cases for temporary connection to construction worksites and other temporary premises. The term granted for temporary connection is usually 24 months.

Where there is a need for the provision of a temporary substation, the customer must provide the site and construct the structure of the substation according to the requirements of SPPA.

There will be a need to install the necessary cables and equipment to facilitate the temporary connection to the distribution network. The customer pays outright costs for the cables and a monthly hiring charge for the use of the equipment (including the cost of insuring the equipment) during the term for temporary connection.

Service Connection Cables

Generally, SPPA supply, install and maintain customer service cable. However, if the customer intake point is at different level to the substation building, or service cable to be installed in cable tray/ladder, the customer shall supply, install and maintain the service cable. In the event that customer supplies the service cable, the customer's LEW shall ensure that the service cable complied with SPPA cable specification, and submit cable sample and specification to Distribution Engineering Section for approval prior to procurement.

5 Mixed Development

For a single plot of land where it comprises of different type of business activities, such as commercial cum residential, the consumer could apply for both HT and LT supplies within the development. For this arrangement, the LEW is responsible to ensure that the supplies are properly segregated and not mixed. The single substation within the plot will provide both HT and LT supplies to the consumer switchroom(s). These two intakes arrangement is only applicable if the intakes are different in voltage level. The LEW is advised to consult SP PowerGrid to ascertain the intake arrangement for mixed development before they proceeds with the design.

The substation within the development could only be decommissioned in future after both the intakes ceased their connections.

6 Types of Service Cables

STANDARD SERVICE CONNECTION CABLES

The type of service connection cables for terminating into a customer's intake point for the applied load connected at the LV and 22kV level and the typical connection schemes are illustrated as follows:

Voltage Level	Applied Load (kVA)	Size of Cables		Type of cables
LV	Up to 15	35mm²	2Core	Cu/XLPE/SWA/PVC
	16 – 45	35mm²	4Core	Cu/XLPE/SWA/PVC
	46 – 75	35mm²	4Core	Cu/XLPE/SWA/PVC
	76 – 140	120mm²	4Core	Al/XLPE/SWA/PVC
	141 – 180	185mm²	4Core	Al/XLPE/SWA/PVC
	181 – 230	300mm²	4Core	Al/XLPE/SWA/PVC
	231 – 280	300mm²	4Core	Cu/XLPE/SWA/PVC
	281 – 460	2x300mm²	4Core	Al/XLPE/SWA/PVC
	461 – 560	2x300mm²	4Core	Cu/XLPE/SWA/PVC
	561 – 1000	7x500mm²	1Core	Cu/XLPE/PVC
	1001 – 1500*	7x1000mm²	1Core	Cu/XLPE/PVC
	1001 – 2000^	2 sets of 7x500mm²	1Core	Cu/XLPE/PVC
	2001 – 3000^	3 sets of 7x500mm²	1Core	Cu/XLPE/PVC
22kV (HV)	Up to 12750kW^	2 sets of 300mm²	3Core	Cu/XLPE/DSTA/PVC
	12751 – 25500kW^	2 sets of 2X300 mm²	3Core	Cu/XLPE/DSTA/PVC
	Pilot cables 1.5 mm²	5 pair		Cu/PE/DSTA/PVC

For development whereby the service connection cables is to be supplied and installed by the customer, the LEW shall, in the event of a non-standard cable installation, seek approval from PG prior to installation.

* applies to upgrading of applied load

^ There must be an electrical and mechanical interlocking bus coupler between each set of cables terminating into the customer's switchboard as shown below :

7 Consumer Connection Agreement

All customers are required to enter into a Consumer Connection Agreement with SPPA and to pay Use of System (UOS) charges. Customers having a direct connection to the transmission system must also pay a service connection charge. For non-contestable customers, the Connection Agreement is part of the Supply Agreement.

The Consumer Connection Agreement for customers taking HT supply at 6.6 kV/22 kV, EHT supply at 66 kV or UHT supply at 230 kV and above will, inter alia, state the Contracted Capacity, which is deemed to be the

requirement for a period of five years. Customers cannot reduce their Contracted Capacity until the expiration of the 5-year period or additional 5-year period. Furthermore, a customer who terminates the supply agreement during the 5-year period or additional 5-year period will be required to pay SPPA through SPSL/Retailer, the Contracted Capacity Charge for the unexpired portion of the 5-year period.

UOS charges are payments for the use of the transmission services. The UOS charges are paid for electricity consumption at each metered intake supply point in accordance with the voltage at which a customer receives the electricity supply. The UOS charges are subject to annual review and the revised UOS charges will be published by SPPA.

In the case of HT and EHT supply to multi-metered premises, the landlord has to enter into a Connection Agreement for the network capacity required for his own load only, i.e. supply for common services, etc.

The UOS Charges are applicable for the following categories of supplies :

- Low Tension (LT) Supplies (400V/230V)

  Supply to Low Tension-Small Consumer

  Supply to Low Tension-Large Consumer

- High Tension (HT) Supplies (22kV and 6.6kV)

  Supply to High Tension-Small Consumer, whose Contracted Capacity is less than 1,700 kW per month at each metered intake supply point.

  Supply to High Tension-Large Consumer, whose Contracted Capacity is at least 1,700 kW per month at each metered intake supply point.

- Extra-High Tension (EHT) Supplies (66kV)

  Supply to Extra-High Tension Consumer

- Ultra-High Tension (UHT) Supplies (230kV and above)

  Supply to Ultra-High Tension Consumer

- Temporary Supplies

  Temporary Supplies apply only to LT and HT supplies for temporary civil engineering and building construction sites.

8 Use of System (UOS) Charges

Low Tension Small Customer

LT supplies (in kWh) to all non-contestable LT consumers are metered on a monthly basis. A flat per kWh UOS rate is levied at each metered intake supply point.

Low Tension Large Customer

The large industrial and commercial LT consumers, who are contestable and have time-of-day metering, come under this category. LT Supplies to these contestable consumers are metered on energy (kWh) on a half-hourly time-of-day basis. The respective per kWh charges shall be levied at a "Peak" and an "Off-peak" period for the energy supplied at each metered intake supply point.

Peak Period Charge

The Peak Period Charge payable shall be the monthly charge based on the energy (in kWh) supplied to an installation during the peak period, 7.00 am to 11.00 pm, in that month.

Off-Peak Period Charge

The Off-Peak Period Charge payable shall be the monthly charge based on the energy (in kWh) supplied to an installation during the off-peak period, 11.00 pm to 7.00 am, in that month.

High Tension, Extra-High Tension and Ultra-High Tension Supplies

For HT (i.e. HT Small and HT Large), EHT and UHT Supplies, UOS Charges shall be levied at each metered intake supply point as follows :

a. Contracted Capacity Charge;
b. Peak Period Charge;
c. Off-peak Period Charge;
d. Reactive Power Charge;
e. Uncontracted Capacity Charge, and
f. Uncontracted Standby Capacity Charge (applicable to consumers with embedded generation who opt to cap their power demand drawn from the network).

Contracted Capacity Charge

The Contracted Capacity Charge is a monthly charge payable in any month for the Contracted Capacity at each metered intake supply point of a consumer. The Contracted Capacity of a consumer's installation shall be the supply capacity (in kW), which is requested for that metered intake supply point. For the avoidance of doubt, and without prejudice to paragraph

3.2.3.1.3 herein, the consumer shall not be allowed to reduce the declared Contracted Capacity upon the signing of the Consumer Connection Agreement / Supply Agreement, notwithstanding the fact that the energisation of the new supply has still not taken place.

For a new supply, the Contracted Capacity shall be deemed to be the consumer's requirement for a binding period of 5 years from the target date or the commissioning date for SPPA's plant and equipment, except for the service cable, whichever is later. For new HT, EHT and UHT supplies, the minimum Contracted Capacity for each metered intake supply point shall be as follows :

HT with 1 or 2 feeders	1,700 kW,
HT with 3 or more feeders	12,750 kW,
EHT	25,500 kW,
UHT	85,000 kW.

For new supplies, a request may be made for intermediate steps before the full Contracted Capacity is implemented during the first year of the 5-year binding period. The first step shall be at least one quarter (¼) of the consumer's requested full Contracted Capacity at each metered intake supply point.

After the initial 5-year period, the consumer may, by giving one month's notice in writing, reduce his Contracted Capacity at each metered intake supply point subject to the following minimum values:

HT with 1 or 2 feeders	850 kW,
HT with 3 or more feeders	6,375 kW,
EHT	12,750 kW,
UHT	42,500 kW

Any such reduction in Contracted Capacity shall be deemed to be the consumer's requirements for one year commencing from the first day of the billing cycle that follows after the end of the notice period and the consumer shall not be entitled to make any further reduction in the Contracted Capacity within one year following any such reduction. Market Support Services Licensee will inform the consumer of the date of their billing cycle.

Upward revision of the Contracted Capacity may be allowed during the validity of the binding period of 5 years or 1 year of the Contracted Capacity. The revised Contracted Capacity shall in such cases commence from the first day in which it is effective and shall apply for the remainder of the initial 5-year period or for a minimum period of 1 year, whichever is the greater, provided SPPA is not required to install new or additional equipment. Downward revision during such binding periods will not be allowed.

A consumer whose revised contracted capacity requires SPPA to install new or additional equipment shall be considered as receiving a new supply with a new 5-year binding period.

For a new development with landlord and tenants, the supply capacity required by the landlord himself must meet the minimum values of 1,700kW and above in order for the landlord to qualify for HT, EHT or UHT supplies.

For those HT, EHT or UHT consumers whose Contracted Capacity are below the minimum values specified above before the implementation of these rates, they may request to increase (but not decrease) their Contracted Capacity in the manner as described above.

Peak Period Charge

The Peak Period Charge payable shall be the monthly charge based on the energy (in kWh) supplied to an installation during the peak period, 7.00 am to 11.00 pm, in that month.

Off-Peak Period Charge

The Off-Peak Period Charge payable shall be the monthly charge based on the energy (in kWh) supplied to an installation during the off-peak period, 11.00 pm to 7.00 am, in that month.

Reactive Power Charge

The Reactive Power Charge is a monthly charge payable in any month for the installation's excess kVArh consumption. The excess kVArh shall be the difference by which the installation's kVArh consumption drawn from the network in that month is greater than 62% of its kWh consumption drawn from the network in the same month.

Uncontracted Capacity Charge

The Uncontracted Capacity Charge is a monthly charge payable in any month for the Uncontracted Capacity utilised. The Uncontracted Capacity is the capacity in kW by which the maximum demand in kW (measured by the half-hour integration meter) exceeds the Contracted Capacity at that metered intake supply point.

The Uncontracted Capacity Charge shall apply to the following HT, EHT and UHT consumers :

a) Normal consumers without embedded generation;

b) Consumers with embedded generation whose monthly maximum demand in kW is the maximum summated demand in kW in the month, determined by summating the kW demand drawn from the network and the kW output from embedded generation (i.e. Summation Scheme); and

c) Consumers with embedded generation who opt to cap their power demand in kW drawn from the network in the event that the maximum

demand in kW (measured by the half-hour integration meter) exceeds the Contracted Capacity at that metered intake supply point (i.e. Capped Capacity Scheme or Extended Capped Capacity Scheme). The Uncontracted Capacity for these consumers shall be limited to 20% of the Contracted Capacity.

Uncontracted Standby Capacity Charge

The Uncontracted Standby Capacity Charge is a monthly charge payable in any month for the Uncontracted Standby Capacity utilised. The Uncontracted Standby Capacity Charge shall apply to those HT, EHT and UHT consumers with embedded generation who opt for the Capped Capacity Scheme or Extended Capped Capacity Scheme.

For Capped Capacity Scheme, the Uncontracted Standby Capacity Charge applies in the event the demand in kW drawn from the network (measured by the power meter) exceeds 120% of the Contracted Capacity at that metered intake supply point for a duration of more than 10 seconds continuously.

For Extended Capped Capacity Scheme, the Uncontracted Standby Capacity Charge applies in the event:

- the demand in kW drawn from the network exceeds 120% and up to 200% of the Contracted Capacity at that metered intake supply point for a duration of more than 100 seconds continuously; or

- the demand in kW drawn from the network exceeds 200% of the Contracted Capacity at that metered intake supply point for a duration of more than 10 seconds continuously

9 Temporary Supplies

Temporary Supplies apply only to LT and HT supplies for temporary civil engineering and building construction sites. The UOS charges applicable for the LT and HT temporary supplies shall be the same as those used for LT and HT supplies respectively.

For temporary supplies at HT, the Contracted Capacity shall apply for a minimum binding period of 1 year up to a maximum of 2 years. Upward revision of the Contracted Capacity may be allowed during the validity of the binding period of the Contracted Capacity. The revised Contracted Capacity shall in such cases apply for a minimum period of 1 year, provided SPPA is not required to install new or additional equipment. Downward revision during such binding period will not be allowed. A consumer whose revised Contracted Capacity requires SPPA to install new or additional equipment, shall be considered as receiving a new temporary supply. The term granted for temporary connection is 2 years.

10 Grid-tied Photovoltaic (PV) Systems

Customers planning to implement Photovoltaic (PV) Systems in their installations and connected in parallel to the SP PowerAssets Transmission and Distribution network are advised to refer to the joint Energy Market Authority & BCA Handbook for Photovoltaic Systems. The handbook provides an overview of the licensing, electricity market, operational and technical requirements etc of PV System installations.

The aim of this technical guideline is to provide Licensed Electrical Worker (LEW), PV supplier and PV applicant the required technical information/requirement to be submitted prior to the installation and turn-on of PV systems.

Consultation with SPPG on technical requirements

After submission of the PV applications to SP Services, LEW has to make the necessary arrangement to discuss with SPPG on the technical requirements. The LEW has to ensure that the following information and/or technical requirements are met before installing the PV systems.

Power Quality for PV system

The customer installation LEW needs to submit and confirm compliance of the Power Quality requirement before installing PV Systems.

Technical Requirements

Harmonics

The generation of harmonics by the PV Systems shall not cause the maximum total harmonic voltage distortion at the PCC to exceed total harmonic voltage distortion of 5%, with no individual odd harmonic greater than 4% and no individual even harmonic greater than 2%. These limits include existing levels of harmonic distortion at PCC.

Voltage Fluctuations including Flicker

The connection of the PV Systems shall not cause voltage fluctuation at the PCC to exceed 3% of the nominal voltage. The connection of the PV Systems shall also comply with Engineering Recommendation P28 – that is it shall not cause the short-term severity value Pst and the long-term severity value Plt at the PCC to exceed 1.0 and 0.8 respectively.

Voltage Unbalance

The connection of the PV Systems shall not cause the maximum negative phase sequence component of phase voltage at the PCC to exceed 1%.

DC Injection

DC injection into the distribution network is deprecated. For inverter based type PV systems, DC injection should not exceed 20mA for PV systems rated up to and including 16A per phase. The connected person shall submit technical justification (including effect on the transmission system) to SP PowerGrid (SPPG) for consideration, if their PV systems DC injection at PCC exceeds this limit.

Voltage Dip immunity

The design operation of the PV systems shall take into consideration that voltage dips occur in the distribution network

EMC Emissions

The PV systems shall meet IEC product family standards on EMC emissions.

Submission of Reports

The licensed Electrical Worker (LEW) shall submit a report to SPPG on the measurement of voltage fluctuation including flicker, and voltage imbalance during connection of their PV systems to the Transmission Licensee's distribution network to confirm compliance with the requirements. The report should be submitted within a month of the PV system connection to the distribution network.

Upon connection of the PV system to the transmission Licensee's distribution network, the LEW shall submit a power quality measurement report to SPPG. The report shall cover a 7 day measurement period at the connected person's incoming switchboard to confirm compliance with the power quality measurements. The report should be submitted within 2 months from the date of PV systems connection to the distribution network.

Power Quality Measurements Provision at the Connected Person's Premises

SPPG may carry out measurements at the connected person's incoming switchboard to verify the submitted measurement reports. The connected person shall make provision at their incoming switchboard to facilitate the connection of SPPG's power quality monitor. All connection and disconnection of SPPG's power quality monitor from the switchboard shall be carried out by the LEW. The monitoring period will be for at least a 7 day period. The monitoring schedule shall be jointly agreed by both parties. However, it shall preferably be not more than 2 months after the PV systems connection to the distribution network. Before the commencement of this work, the connected person has to agree and sign SPPG's testing /measurement services agreement.

Connection Requirements

Besides the above reports to ensure compliance of the connection are to be submitted to SPPG, the LEW must also carry out anti-islanding test in the presence of the SPPG project officer during the commissioning of the intake point.

TOPIC 3: PROCEDURES FOR APPLICATION & TURN-ON OF ELECTRICITY SUPPLY

1 Procedures for Application of Electricity Supply

1.1 Submission of Consultation Form

For direct connection to Grid, customer may seek consultation on the technical requirements at the conceptual/planning stage by submitting Consultation Form through the Licensed Electrical Worker (LEW) to SP PowerGrid.

SP PowerGrid requires information such as site & location plans, gross floor area, type of premises and business activity, supply requirement and expected date of energisation.

1.2 Submission of Application for Direct Connection Load ≤ 45 kVA

The LEW, on behalf of customer, shall submit an Application Form with 1 copy of site & location plans showing proposed intake connection point to SP Services to apply for new or modified connection to the Transmission System.

SP Services shall endeavour to send the quotation for electricity supply connection to the customer within 10 business days.

Customer pays Service Connection Charge within the validity period of the quotation.

Upon receipt of payment, SP PowerGrid will commence work and inform the customer and LEW on completion.

Customer shall open an utilities account and pay security deposit to SP Services.

The LEW shall submit Online Form CS/5 - Application for Inspection of Electrical Installation on behalf of the customer, and attach a copy of Certificate of Compliance (CoC) together with Form CS/12 – Application for Electrical Installation Test to request for an inspection and turn-on by SP Services and Letter of consent form.

(Note: First-time inspection is free-of-charge)

1.3 Submission of Application for Indirect Connection Load ≤ 45 kVA

Customer shall open an utilities account and pay security deposit to SP Services.

The LEW shall submit online Form CS/5 – Application for Inspection of Electrical Installation on behalf of the customer together with the landlord's consent on Form CS/3 – Letter of Consent from the Landlord/ Management Corporation or Form CS/3H – Letter of Consent from Housing & Development Board together with Form CS/12 – Application for Electrical Installation Test and a copy of Certificate of Compliance (CoC) and Letter of Consent from customer to request for an inspection and turn-on by SP Services.

(Note: First-time inspection is free-of-charge and Form CS/3 or Form CS/3H is not required for HDB residential premises)

1.4 Submission of Application for Direct Connection Load > 45kVA

The LEW shall submit an Application Form with 1 copy of site & location plans showing proposed intake connection point, on behalf of the customer.

SP Services shall advise the LEW & customer on the approval of the application & technical requirements within 10 business days for connections up to 22kV, within 60 business days for 66kV connections and within 100 business days for 230kV connections.

For Service without sub-station, the procedure is the same as for Direct Connection Load ≤ 45 kVA.

For Service with sub-station, LEW shall submit sub-station plan & metering requirements to SP PowerGrid for clearance.

SP Services shall send to customer the Quotation, Agreement, Deposit amount required for Opening of utilities account.

On receipt of payment for service connection charge & signed agreement, SP PowerGrid will commence work & inform LEW & customer on completion.

Customer shall proceed to open an utilities account with SP Services together with a security deposit and instruct his LEW to apply to Energy Market Authority (EMA) for Electrical Installation (EI) Licence.

The customer shall subscribe and activate 1 functional telephone line per metering point for remote meter reading purposes, if applicable.

LEW shall submit a copy of CoC, EI Licence and IRAS letter stating official address (if applicable) to Installation Section of SP Services @ 1A

Woodleigh Pk Office to request for an appointment for energisation of service connection with SP PowerGrid.

1.5 Submission of Application for Indirect Connection Load > 45 kVA

Once the premises is ready for installation of meters, the customer shall proceed to open an utilities account with payment of security deposit to SP Services.

The LEW shall proceed to apply to EMA for EI Licence before the electricity supply is turned on.

The LEW shall submit Form CS/3 or Form CS/3H, online Form CS/7 - Request for Installation of Electricity kWh Meter (for Load Exceeding 45kVA) and a copy of CoC and EI Licence to SP Services declaring the account activation date (which is the proposed turn-on date).

The LEW shall proceed to liaise with Meter Section of SP PowerGrid to install meters.

For HT Supply (including HT sub meter), the consumer is required to sign an agreement with SP PowerGrid before SP Services can process the application for installation of TOD meter.

The LEW shall be responsible for arranging the energisation of the service connection with the relevant party where the connection is taken via landlord's switchboard such as HDB, JTC or private multi-tenanted buildings.

Landlord's LEW shall issue the Statement of Turn On of Electricity (SOTO) upon successful turn-on.

1.6 Submission of Application for New EHT & HT Consumers Who wish to be Contestable at time of Turn-On

The procedure is similar to Direct & Indirect Connection Load > 45 kVA. In addition, the consumer must subscribe and install one dedicated telephone line per metering point (adjacent to meter panel) to be used for the purpose of remote metering.

The LEW shall submit a copy of the duly completed online Form CS/6 – Request from Contestable Customer for Installation of Electricity kWh Meter with the active dedicated telephone line number clearly stated to SP Services for the installation of TOD Meter.

The LEW shall proceed to liaise directly with Meter Section of SP PowerGrid to have the TOD meter installed.

Upon completion of the installation of the TOD meter and telephone line, the consumer shall submit a copy of the duly completed Application

for Contestability Status and Application to open a MSS Account to Client Relations Branch of SP Services at 10 Pasir Panjang Road, #03-01, Mapletree Business City, Singapore 117438 or via fax: 6304 8633at least 12 business days prior to the arrangement for the turn-on appointment.

If the customer chooses to purchase electricity from a Retailer with effect from the turn-on date, the Retailer must submit a transfer request to SP services at least 1 business day before the turn-on date.

Otherwise, SP Services will arrange to buy electricity for the customer from the wholesale electricity market and the customer will be charged for the electricity consumption at prevailing wholesale spot prices. In this case, a security deposit to SP Services is required.

The LEW shall proceed to apply to EMA for EI Licence.

The LEW shall submit a copy of CoC, EI Licence, IRAS's Letter stating official address and book an appointment for energisation of service connection at Installation Section of SP Services @ Singapore Power Training Institute, 1A Woodleigh Park, #01-03/04 Singapore 357874 (for HT Supply) or at Transmission Projects Section of SP PowerGrid @ Kallang Bahru District Office (for EHT Supply).

1.7 Submission of Application for Modification of Electrical Installation (Exempted From Licensing)

The LEW shall submit to SP Services the duly completed online Form CS/5, together with Form CS/3 or Form CS/3H and the Completion Certificate for Modification of Electrical Installation on behalf of the customer.

(Note: First-time inspection is free-of-charge and Form CS/3 or Form CS/3H is not required for HDB residential premises)

SP Services conducts spot-checks for those system-selected applications.

For those applications not selected, acknowledgement letters will be sent to both the customer and the LEW.

If the inspection is "Failed", the LEW will have to come to SP Services with a copy of the "Failed" letter to arrange for a re- inspection and a re-inspection fee is payable.

If the inspection is "Passed", acknowledgement letter will be sent to both the customer and the LEW.

1.8 Overview : Contestability

Contestability started in July 2001 and was launched in stages. It is to encourage competition and provide more choices for customers. With contestability, customers are now able to

- Purchase electricity from licensed electricity retailers (Retailer Consumer)
- Purchase electricity directly from the spot market as a direct market participant (Direct Market Consumer)
- Purchase electricity indirectly from the spot market through SP Services Ltd (MSSL Consumer)

SP Services Ltd, as the MSSL,

- Provides regulated Market Support Services such as retail settlement, meter reading and meter data management,
- consumer registration and transfer processing for contestable consumers who switch from one retailer to another.
- Provides billing and payment collection of transmission service charges on behalf of SP PowerAssets Ltd.
- Facilitates indirect access to spot market by retailers or by contestable consumers who have not signed up with retailers.
- Supplies electricity to non-contestable consumers at regulated tariff.

The retailers are:

- Keppel Electric Pte Ltd
- SembCorp Power Pte Ltd
- Senoko Energy Supply Pte Ltd
- Seraya Energy Pte Ltd
- Tuas Power Supply Pte Ltd

The following types of non domestic consumers are eligible to apply for contestability:

- Low tension, 3 phase supply with an average of at least 2,000kwh consumption per month
- High tension supply
- Extra high tension supply
- Ultra high tension supply

2 Procedures for Turn-on of Electricity Supply

2.1 Types of Installations Required Checking by MSSL

- Small Electrical Installation
  (Supply capacity not exceeding 45 kVA)
- Large Domestic Electrical Installation
  (Supply capacity exceeding 45 kVA)
- Residential units in Condominium / Conventional Housing Development
- HDB Residential Units
- Bulk Replacement of Meterboards in multi-tenanted Building

2.2 Inspection of Small Electrical Installation (Supply Capacity ≤ 45kVA)

- Customer shall open an account with SP Services. The LEW then submits online Application For Inspection of Electrical Installation (Form CS/5) and attach Certificate of Compliance (COC) to apply for an inspection appointment at Supply Application (SA) Section of SP Services. Upon confirmation, SA Section arranges and issues inspection appointment letter to the LEW;

- Meter Section of SP PowerGrid will install meter one day before the inspection date;

- SP Services attends to the inspection appointment;

- Inspection of electrical installation is carried out in accordance with SS CP5 (Code of Practice For Electrical Installation) and the relevant regulations;

- For direct grid connection, LEW submits Certificate of Readiness (COR) to SP Services on site;

- The electricity supply will be turn-on if the inspection result is 'Passed';

- SP Services (on behalf of SP PowerGrid- for direct grid supply) or LEW issues "Statement of Turn On of Electricity" and acknowledged by the LEW and applicant or his representative;

- If the inspection result is 'Failed', LEW must rectify the non-compliances, pay a re-inspection fee and re-submit COC to apply for re-inspection appointment;

- A copy of the SP Services inspection report will be given to the LEW and applicant or his representative on site. Violation clauses on the electrical installation will be sent to EMA.

2.3 Inspection of Large Domestic Electrical Installation (Supply Capacity > 45kVA)

- LEW submits application for service connection if directly connected to Grid's network;
- LEW installs electrical installation in accordance with the single-line drawing (SLD);
- Customer opens an account with SP Services;
- LEW submits COC, Form E, SLD, IRAS and Account Opening Letter to Installation Branch of SP Services (Located at SPTI, 1A Woodleigh Park) to request for inspection appointment;
- Installation Branch checks the submitted documents and issues an appointment letter, if documents are in order;
- LEW liaise with Meter Section of SP PowerGrid for fixing of meter;
- Meter Section installs meter at least one day before the inspection appointment date;
- On the appointment day, LEW submits COR to SP PowerGrid's Project Officer on site (for direct Grid connection);
- SP Services carries out inspection on the electrical installation in accordance with SS CP5 (Code of Practice For Electrical Installation) and the relevant regulations;
- SP PowerGrid energise the service connection (for direct grid connection) and LEW will turn-on the electricity supply to the electrical installation if the inspection result is "Passed";
- SP PowerGrid / LEW will issues a "Statement of Turn On of Electricity" to the LEW and Applicant or his representative;
- If the inspection result is failed, LEW must rectify the defects, pay a reinspection fee and re-submit the COC & Form E to request for a re-inspection appointment;
- A copy of the SP Services inspection report will be given to the LEW and applicant or his representative on site. Violation clauses on the electrical installation will be sent to EMA.

2.4 Sample Unit Inspection of Electrical Installations in Private Residential Development

- Upon completion of the electrical installations works of all the residential units in a block, LEW carries out his own testing of the electrical installations and certifies Form E for all the residential units of the block;

- LEW submits the Form E, SLD and IRAS Letter (stating the list of official addresses of the residential Units) to request for an appointment for sample unit inspection at Installation Branch located at 1A Woodleigh Park, SPTI;

- Installation Branch will notifies Meter Section of SPPG to conduct a separate inspection on the meterboards set-up;

- On the appointment day, SP Services conducts a 100% inspection on the sample units which are randomly selected from the block in the presence of the LEW;

- Upon successfully inspected the randomly selected sample units and passed the inspection by SP Services, and the meterboards set-up cleared by SPPG Meter Section; SP Services notifies Meter Section to bulk fix meters to all the residential units;

- LEW may proceed to liaise with Meter Section to bulk fix the meters for all the residential units in the block;

- After all meters have been installed to the residential units, LEW submits COC to Installation Branch to request for pre-turn-on inspection appointment;

- On appointment day, SP Services conducts pre-turn-on inspection to all individual units;

- Upon successful inspection of each residential unit of the block, LEW turn on the electricity supply up to meterboard and issues "Statement of Turn On of Electricity";

- SP Services will send a letter of completion to the LEW and developer to inform of the completion of the unit inspection;

- Developer will then release the units keys to the buyers;

- Electricity supply to the residential unit will only be turn-on after the owner of the individual unit opens an account with SP Services;

- If there are non-compliances found in the electrical installations which cannot be rectified during the inspection, a failure letter will

be issued to the LEW and copy to the developer as well as Energy Market Authority;

- ❖ LEW must rectify the non-compliances, pay a re-inspection fee and re-submit the documents to request for an appointment for re-inspection;

- ❖ In order to prevent developer from releasing the keys to the buyers before the completion of the inspection, SP Services will help to send a letter to the developer reminding them of the requirement for their LEW to apply for the unit inspection, when the LEW request for the turn-on to the main switchboard. However, SP Services is under no obligation to send this reminder letter. It is an initiative taken by SP Services to help LEW in informing the Developer.

2.5 Inspection and Pre-Turn-On of HDB Residential Units

- ❖ Upon completion of the electrical installations works of all the residential units in a block, LEW carries out his own testing of the electrical installations and certifies Form E for all the residential units of the block;

- ❖ LEW submits COC, Form E and SLD of each of the premises type to HDB for certification;

- ❖ HDB conducts own testing and submits certification letter to Installation Branch of SP Services together with the LEW endorsed COC, Form E and SLD to request for appointment to inspect & pre-turn-on the residential units;

- ❖ HDB arrange with Meter Section of SP PowerGrid to bulk fix meters to all residential units in the block;

- ❖ On the appointment day, SP Services conducts a sample units inspection for each of the unit types in the blocks;

- ❖ If sample unit inspection passed, SP Services proceed with the pre-turn-on inspection to all the units in the block;

- ❖ Upon successful inspection of each unit, electricity supply is turn-on to the unit DB;

- ❖ LEW issues "Statement of Turn On of Electricity" for the block with acknowledgment by HDB;

- ❖ SP Services displays a "Caution" sticker and a guidance booklet at the unit DB informing the owner to check the electrical installation before use, as well as to open an account with SP Services;

- If there are non-compliances found in the electrical installations which cannot be rectified during the inspection, a failure letter will be issued to the LEW and copy to HDB as well as Energy Market Authority;

- LEW must rectify the non-compliances, pay a re-inspection fee and request for an appointment for re-inspection.

2.6 Inspection of Bulk Replacement of Meterboards

- LEW submits online Form CS/5 to Electricity Supply Application Section for bulk replacement of meterboards in multi-tenanted building;

- LEW submits meterboard layout plans to Meter Section of SP PowerGrid for approval;

- LEW submits Form P together with shut-down notice issued by Town Council/Managing Agent, to obtain permission from SP Services to break meter terminal seal for the replacement of meterboards;

- LEW inspect & test the meterboards and submain cables replaced and certifies Form F – Certification of Bulk Shifting/Replacement of Meterboards in Tenanted Buildings;

- LEW submits certified Form F, acknowledged Form P, SPPG's approval letter and SLD to Installation Branch to request appointment for inspection of bulk replacement of meterboards;

- Appointment will be arranged if documents submitted are in order;

- On the appointment day, SP Services carries out the following inspection in the presence of the LEW:
  (i) Visual inspection of meterboard set-up;
  (ii) Meter number and unit address to tally with meter listing in SP Services' records;
  (iii) Meters are not transposed with the neighboring units;
  (iv) Meter rotation and Polarity check of one SSO inside the unit

- SP Services re-seals all meter terminals after inspection;

- A completion inspection letter will be issued to the LEW and Landlord/MCST.

3 Related Information

For more information on Electricity Supply Application, you can refer to the Handbook "How to apply for Electricity Connection".

Alternatively, you can view the handbook from **http://www.sppowergrid.com.sg** or visit **http://www.spservices.com.sg** for more information on the New Electricity Market.

4 Important Contact Numbers

SP SERVICES LTD	**Tel No**	**Fax No**
General Enquiry on Application For Connection to Transmission System	66717122	6304 8289
Consumer Connection Agreement		
Contracts Section	66717123	6304 8289
Testing and Turn-on Appointment		
Supply Application Section	66717122	6304 8289
Installation Section	63092600	63092614
Opening of Utilities Accounts		
Enquiry	1800-2222333	6304 8229
SP POWERGRID LTD		
Endorsement of Substation Drawings		
• East zone	3788557	68238564
• West zone	3788679	68238564
Installation of Meters		
Enquiry	68764848	62743913

TOPIC 4a : PROCEDURES FOR FIRST ENERGISATION TO NON-DOMESTIC CONSUMER'S ELECTRICAL INSTALLATION EXCEEDING 45KVA

1 Prior to Energisation

1.1 Contestable Consumers

- A Consumer Connection Agreement, containing the service connection charge payable, the offer letter and the standard terms and conditions with respect to the distribution service connection.

- If a substation is required, a letter stipulating the requirements will be forwarded to the customer, and an Agreement offered after the substation's plans are endorsed.

1.2 Non-Contestable Consumers

- A Quotation, containing service connection charge payable and the conditions of service with respect to the distribution service connection.

- If a substation is required, a letter stipulating the requirements will be forwarded to the customer. A Supply Agreement including the service connection charge payable and the terms and conditions with respect to the distribution service connection, is offered after the substation's plans are endorsed.

1.3 Obtain Licence for Electrical Installation (EI) from EMA

1.4 Open Account with Market Support Services Licensee (MSSL)

1.5 Pay Security Deposit

2 Roles of LEW

2.1 Supply Capacity > 45 kVA Up to 22 kV (Directly connected Consumers)

- To supervise and ensure that the electrical set up is in accordance with the relevant Codes of Practice (CP) and Regulations

- Ensure equipment tested (inclusive of Protection System) and Safety Inspection carried out
- Arrange for meter fixing and testing by Meters Section
- Submit Certificate Of Compliance (CoC – i.e. Form 4.1) when arranging appointment for Energisation

2.2 On the day of Energisation

- Submit Certificate Of Readiness (CoR – i.e. *Form 4.2*) to SP PowerGrid's (SPPG)
- Perform Interlocking Tests on Incoming Circuit Breaker (CB)
- Perform Tripping Tests on Incoming CB

2.3 Immediately after Energisation

- Phasing of Incoming Supplies
- Acknowledge on the Statement of Turn-on of Electricity (Form 4.3)

3. Lead-Times for Application for Service Connection

3.1 The timely provision of electricity supply to a development involves the joint efforts of SPSL, SPPG, and the customer and his agents, such as the LEW. While SPSL and SPPG will make every effort to engineer and implement the connection scheme, it is at the same time essential for the new customers and their agents to play their part such as the early submission of applications and plans, the acceptance of terms and conditions of connection including making the necessary payments and the compliance of the necessary SPPA or Transmission Code requirements.

3.2 As a guide for the customer and his agents, the normal lead-times for the various events are listed on the following page. Depending on the progress and completion time of precedent events, the actual completion dates of events leading to the energisation of the service connection may need to be reviewed and adjusted.

3.3 To promote investment and entrepreneurship, industrial development applying Low Tension supply may be considered for fast track connection scheme. Eligible applicant should meet the following criteria:

(a) Load application of 76 to 140 kVA; and

(b) Point of supply connection not exceeding 150m away from existing network source.

Applications under such fast track connection scheme will receive their supply in 23 days from date of submission of application to SPSL

Form 4.1

CERTIFICATE OF COMPLIANCE

Particulars of Electrical Installation

Name of Consumer: _____

Address of Installation: _____

_____

Electrical Installation Licence No.: _____ MSS Account No.: _____

Approved load & Supply Voltage: _____ kW _____ Volts

Generator(s) Installed: ☐ Operated in parallel with PowerGrid's network.
No. of generator: _____ Rating: _____ kVA

☐ Standby generator.
No. of generator: _____ Rating: _____ kVA

☐ Not applicable

Electrical Installation Design Certification

I certify that the design of the above-mentioned electrical installation complies with the requirements of the Electricity (Electrical Installations) Regulations 2002 and the relevant Singapore Standard Code of Practice. With the certification of compliance by the LEW responsible for the installation work as shown below, I hereby request for the energisation of the supply line to the said electrical installation on _____ (date).

_____	_____	_____
Name & Signature of LEW responsible for design of electrical installation*	Licence No.	Date

Electrical Installation Inspection Certification

I have supervised the work of the above-mentioned electrical installation and hereby certify that the electrical installation complies with the requirements of the Electricity (Electrical Installations) Regulations 2002 and the relevant Singapore Standard Code of Practice. I further certify that the technical requirements as stipulated by the person responsible for turning on the switchgear which controls the supply of electricity to the said electrical installation have been complied with.

_____	_____	_____
Name & Signature of LEW responsible for electrical installation work*	Licence No.	Date

* The same LEW may perform both design and installation work for the electrical installation.

Copy to:

Market Support Services Licensee

Form 4.2

CERTIFICATE OF READINESS FOR THE ENERGIZATION OF SERVICE CONNECTION (COR)

Name of Customer Installation: _____
Address: _____
Customer Installation Licence No/Expiry Date: _____
Connection Voltage: _____
Approved Load: _____
Name of Connection Cable(s): _____
Owned by Connection Applicant (Yes / No) _____
MSS Account No: _____
Name of Retailer: _____

Certification By LEW

I, _____(name) the undersigned LEW, hereby certify that the service connection*, the equipment and works at the above installation (Licence No: _____) are now ready and fit for energisation with effect from the date and time specified below.

Date:
Time:

I certify that:

a. Protection details are as follows:

CT Ratio: _____ /1A or 5A*
Short-Time Withstand Current Ratings of Main Supply Incoming Switchgear _____ KA for 1 sec or 3 sec

Main 1 Type: _____
Main 2 Type*: _____ Direct Acting Tripping Setting: _____
O/C Type: _____ Setting: _____
E/F Type: _____ Setting: _____

b. The switching equipment/transformer/service connection* and all associated apparatus related to the service connection have been tested and checked by me and they have passed the pre-commissioning checks and tests in compliance with the Market Rules, Transmission Code, Handbook on How to Apply for Electricity Connection, Connection Agreement, all other applicable standards, and the associated protection systems have all been proven effective.

c. The main protection schemes for the connection have been commissioned by load simulation method on date: _____**

d. For multi-metered installation with the exception of HDB residential installation, the metering scheme has been designed as master/sub-metering scheme.

e. All necessary meters have been installed.

* Delete where not applicable
** To indicate NA where protection scheme is not applicable

Form 4.2

f. The safety coordination requirements of the Transmission code have been fully complied with.

g. All workmen have been withdrawn and warned that it is no longer safe to continue to work on the equipment without a 'Permit-to-work (PTW)', and that all tools, scaffolding, ladders, construction materials including any temporary local earthing connections have been removed from the equipment, and all protective screens or guards, if any, have been securely fixed and the appropriate warning signs displayed and that all keys, if any, necessary for the isolation and operation of the equipment have been handed to me.

h. All circuit earth on equipment to be energised are removed.

i. Equipment to be energized in this request (the diagram must clearly indicate the portion of the equipment to be energized. If the space is insufficient, please provide diagram as attachment) is shown below:

Name & Signature of LEW requesting for energization of supply line	Licence No.	Date

Form 4.3

STATEMENT OF TURN–ON OF ELECTRICITY

ELECTRICITY SUPPLY TO _____
(Name of Applicant)

AT _____
(Address of Installation)

_____

ELECTRICAL INSTALLATION LICENCE NO* : _____

APPLICATION NUMBER: _____

I agree that the above-mentioned electrical installation is suitable for connection to the electrical system. I certify that the supply line to the installation has been energized on

_____ at _____
(Date) (time)

_____	_____	_____
Name & Signature of PowerGrid's Officer	**NRIC No.**	**Date**

I acknowledge that the supply line has been energized on the date and time indicated above.

_____	_____	_____
Name & Signature of LEW requesting for energization of supply line	**Licence No.**	**Date**

I acknowledge that the supply line has been energized on the date and time indicated above and confirm that I will be responsible for the operation of this electrical installation hereafter.

_____	_____	_____
Name & Signature of LEW responsible for the operation of the electrical installation*	**Licence No.**	**Date**

I acknowledge that the supply line has been energized on the date and time indicated above.

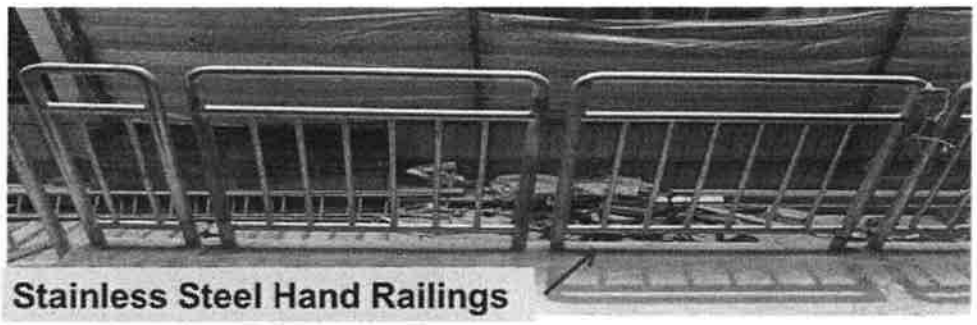
_____	_____	_____
Name & Signature of Applicant or His Representative	**NRIC / Passport No.**	**Date**

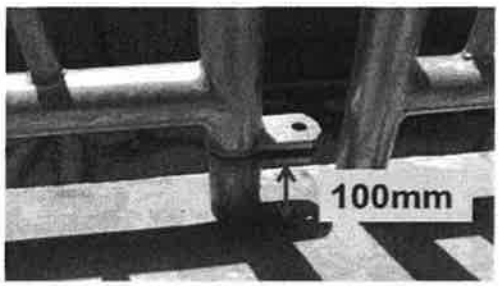
* Not Applicable for an electrical installation that is exempted from licensing.

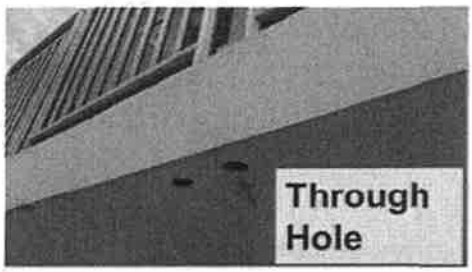
Original Copy - PowerGrid Ltd
Pink Copy - LEW (Requesting)
Yellow Copy - LEW (Operation)
Green Copy - Applicant
Blue Copy - MSSL
White Copy - File

TOPIC 4b: SITE REQUIREMENTS

1 Substation Requirements

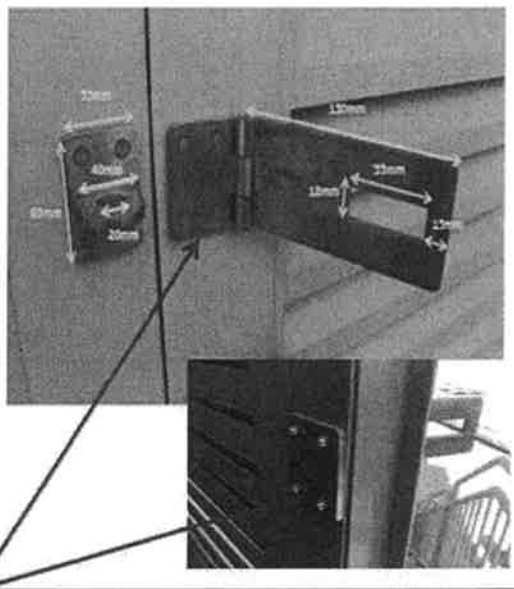




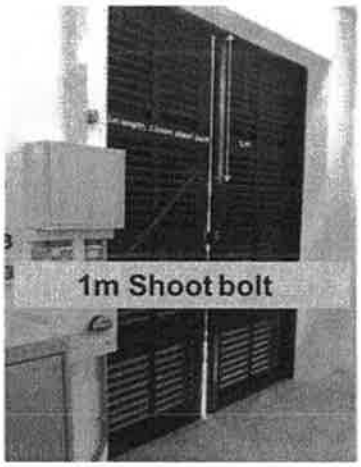


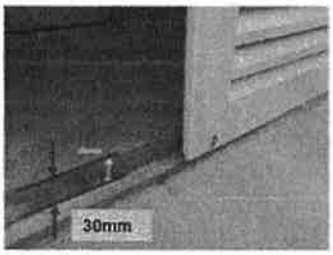
Removable Steel Hand Railings Facing the Substation Door





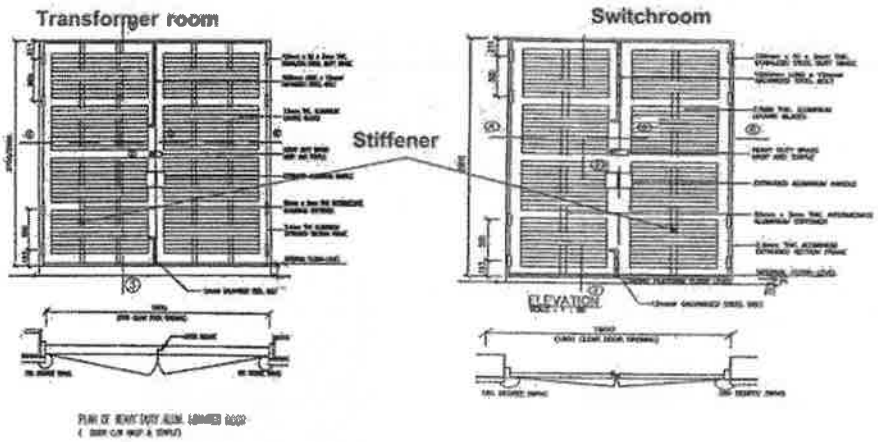
Based plate of Hasp & staple to be installed and firmly secured for both front and back



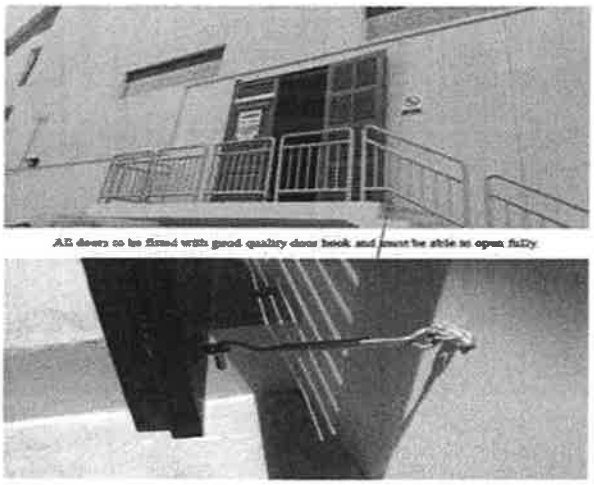




Shoot-bolt for substation door to be properly fixed and ensure no jamming

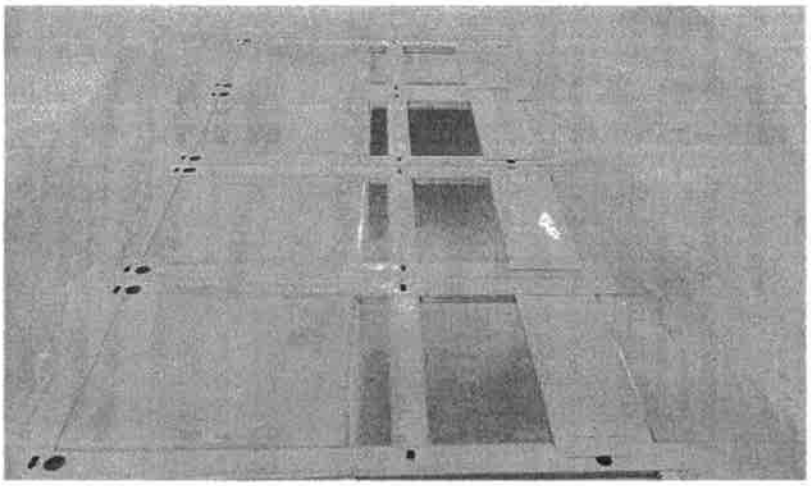


To provide stiffeners for the switchroom and transformer room

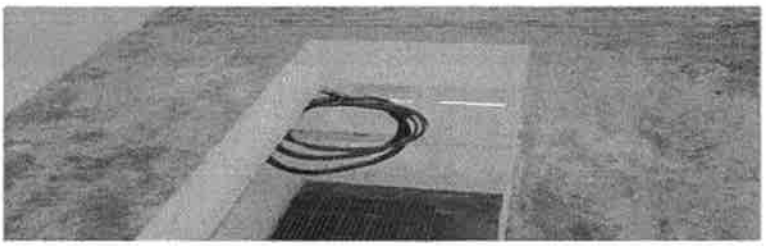


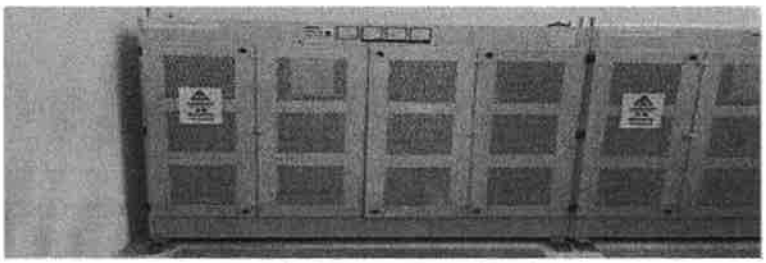
All doors to be fitted with good quality door hook and must be able to open fully

Door catch is to be properly installed for all substation doors



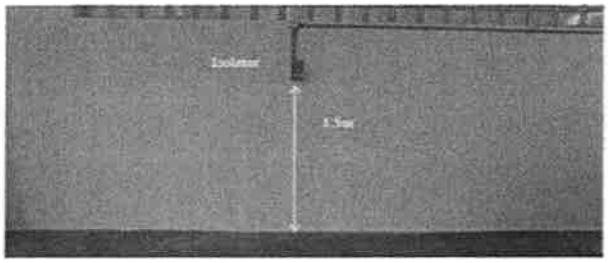
Screed the floor 5mm below the floor frame, after the floor frame had been fixed





LT Board – 2200mm x 600mm x 1850mm

Provide (2x25mm2) +16mm2 Cu Cable with 1m of Flex hose and hot gland

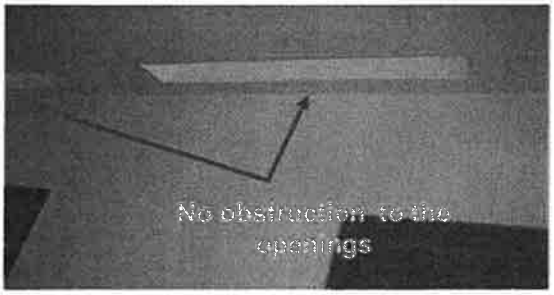




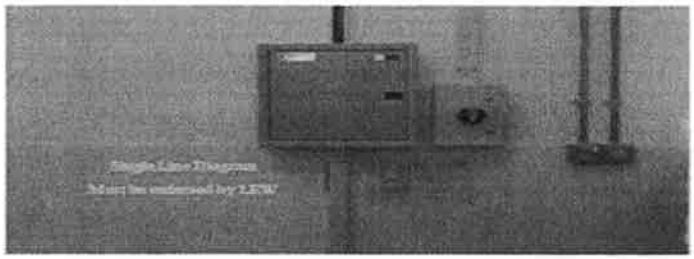
Isolator to be installed at 1.5m from the floor

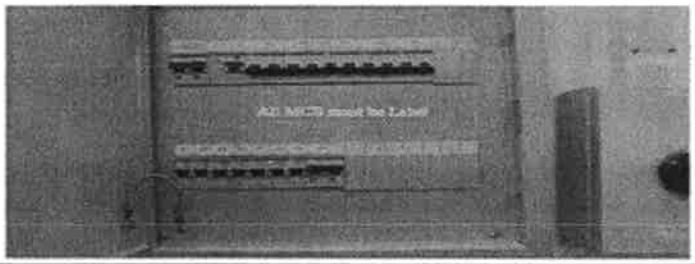




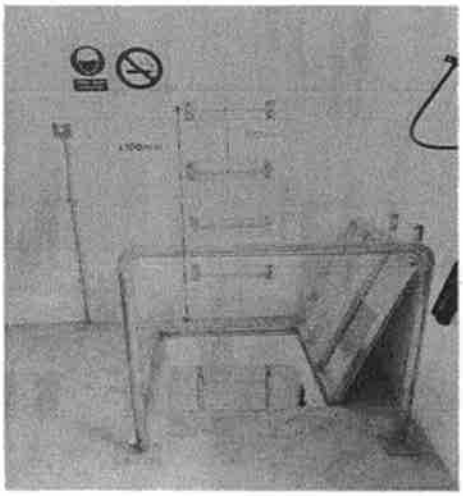


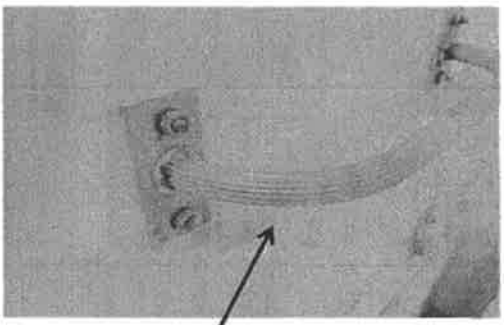
Opening for Marshaling Box, Pilot Box & Battery Charger





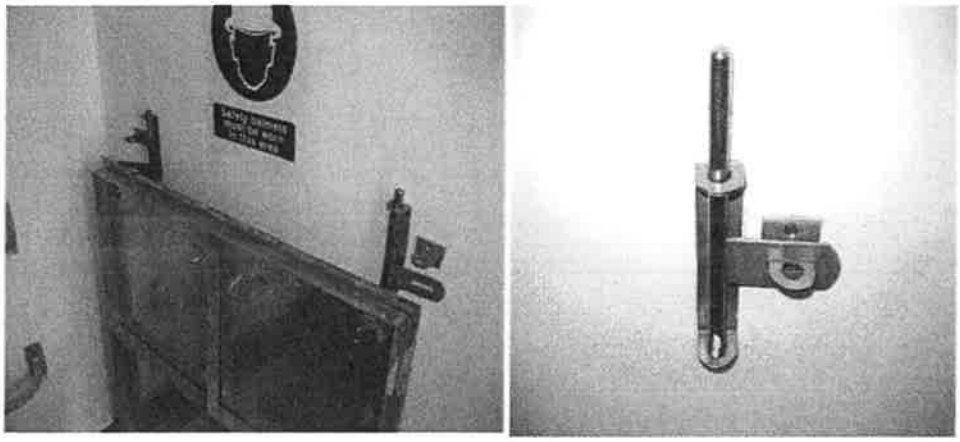
SLD to be endorsed by LEW and MCB Board to be labelled accordingly





Non-skid type

To provide non-skid grip for the cat ladder rung



Non removable type wall catch

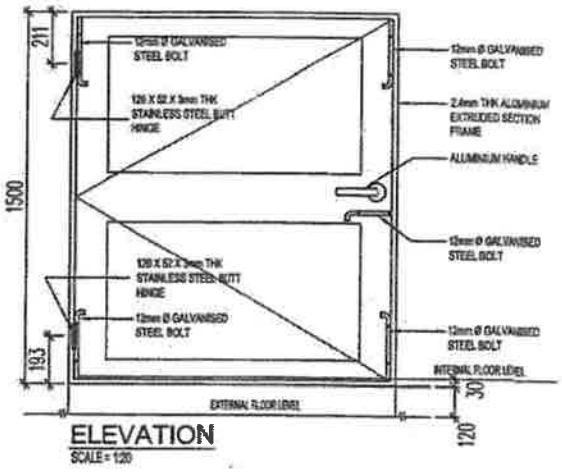
To install wall catch for trap door cover with removable type



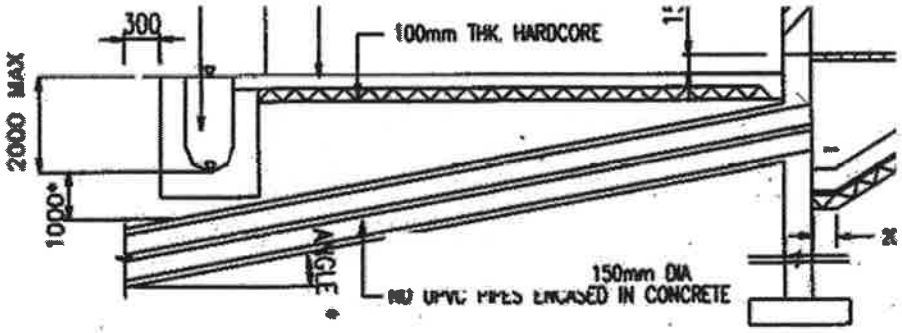


Clear display of Signage



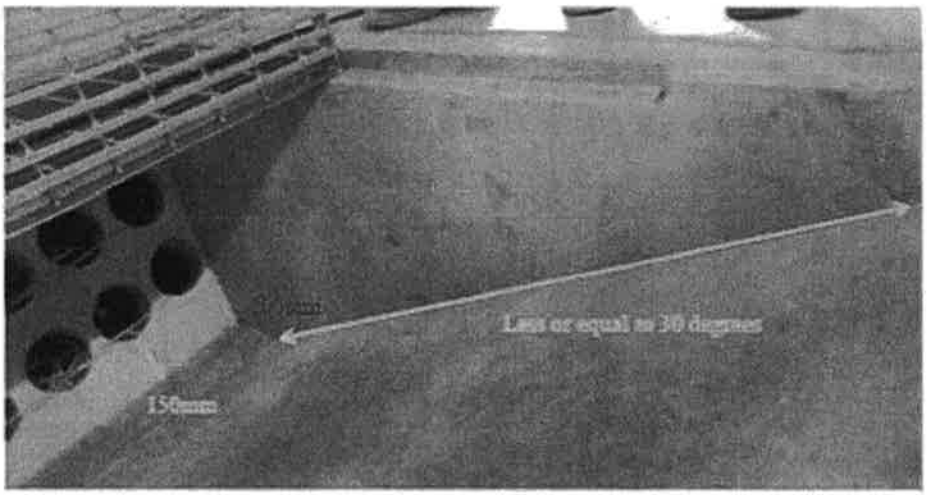


To provide five numbers of 12mm dia galvanised steel bolts

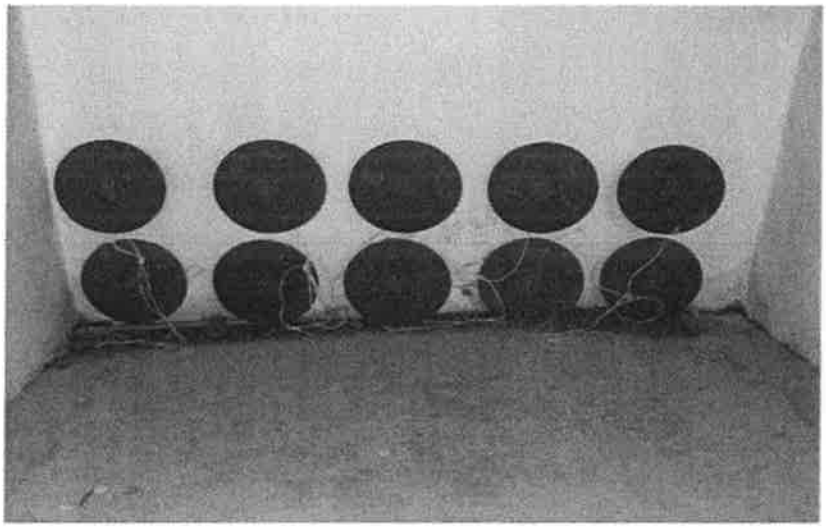


DETAIL OF CABLE RAMP AND ENTRY PIPES
SECTION X - X

UPVC cable entry pipe to be terminated beyond roadside drain

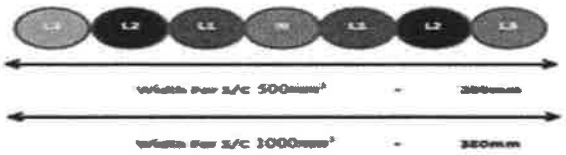


To be flushed with wall and no sharp edges around them

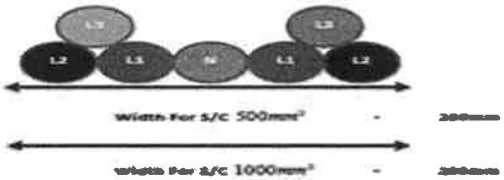


All the pipes are to be covered with removable water-tight plug

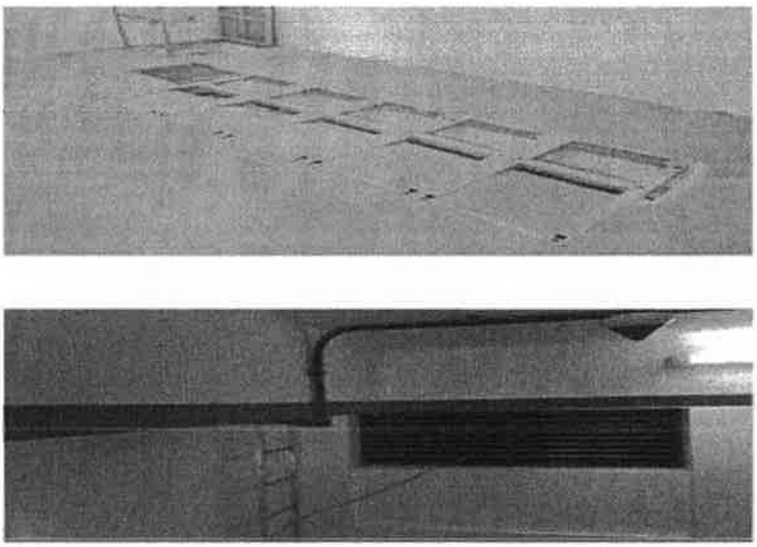
Arrangement 1



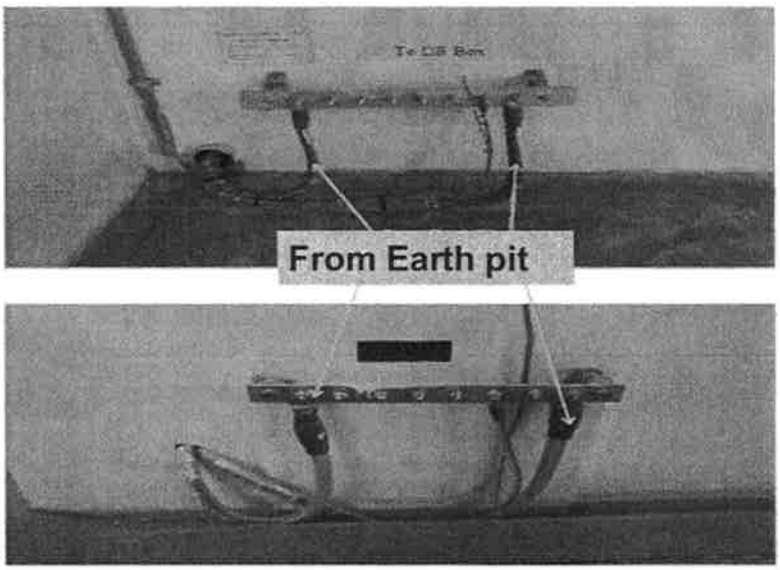
Arrangement 2



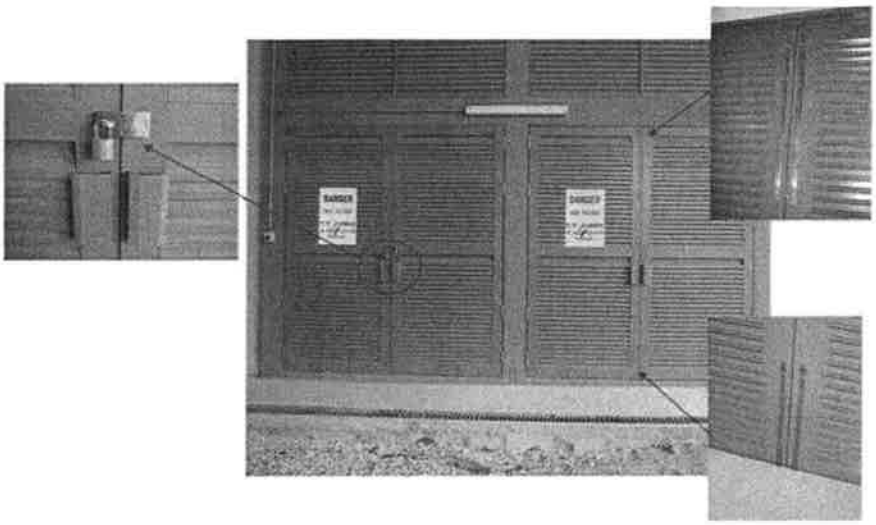
Arrangement of 500*mm* or 1000*mm*Cu single core cables is carried out as shown below so that the current in each phase is evenly distributed between the cables for that phase.



To ensure 50mm red luminous paint is painted on the front and back of all beams at the cable chamber



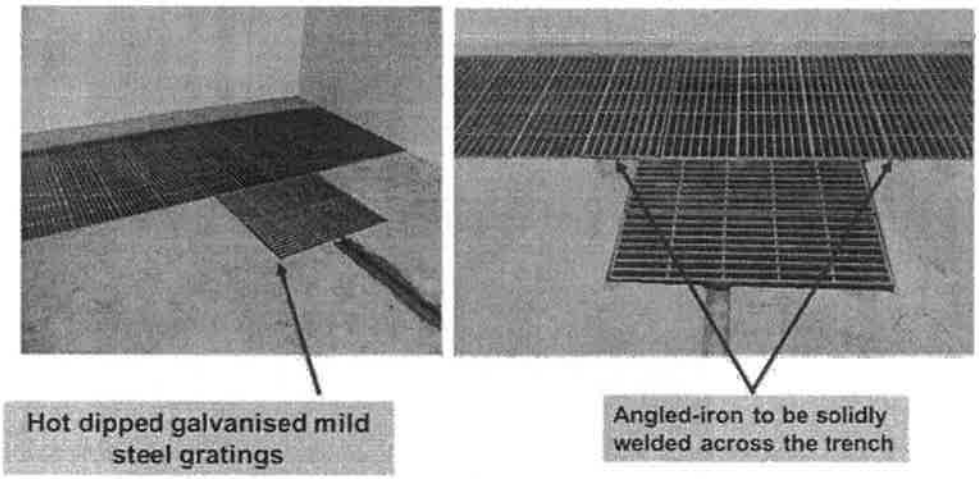
Earthing for the substation at cable chamber room



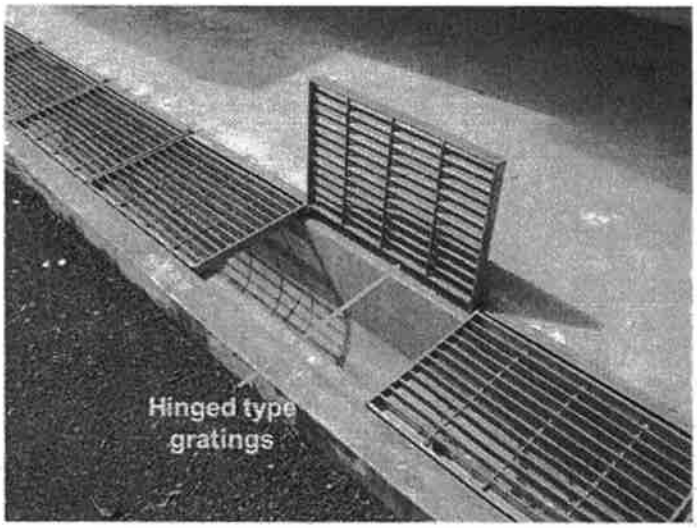
To install hasp and staple for one transformer room door only



Groove to be provided at the base of the Transformer



To provide hot-dipped galvanised mild steel gratings for LT and HT opening trenches



To install hinged hot dipped galavanised mild steel grating for drainage around substation

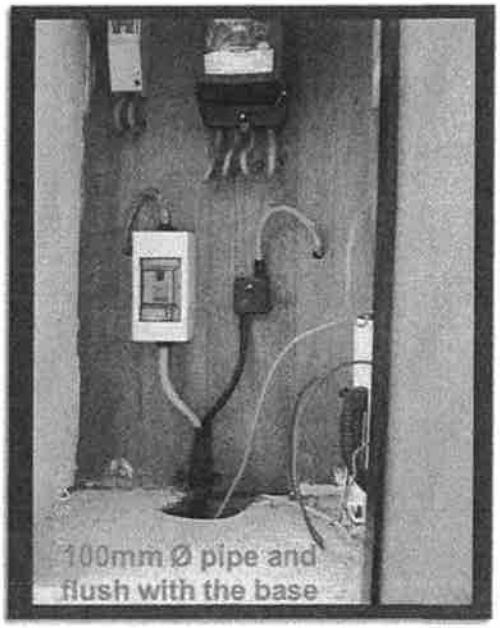


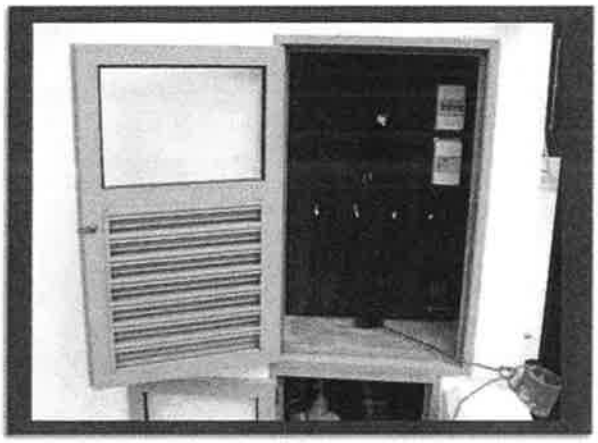
To install embedded concrete base for substation fencing

2 Meter Compartments At Gate Pillar

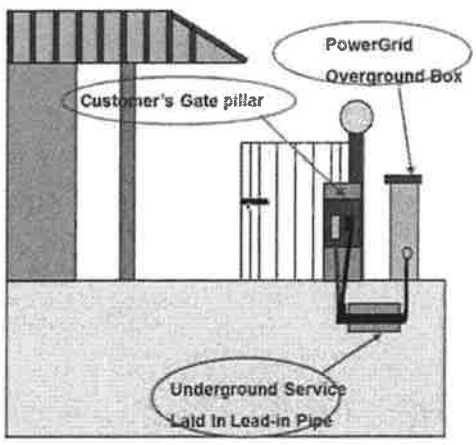
Common deviations

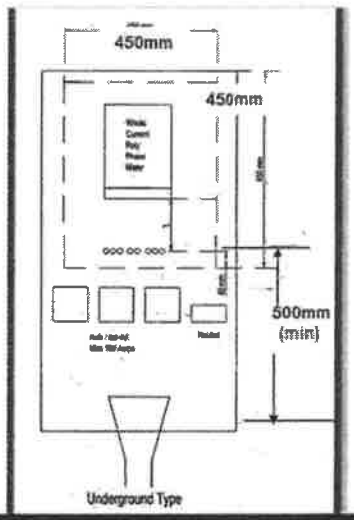
- Entry pipes not correctly aligned with meter board
- Incorrect size entry pipe installed
- Entry pipes not flushed with meter compartment concrete base





To provide proper meter compartment door

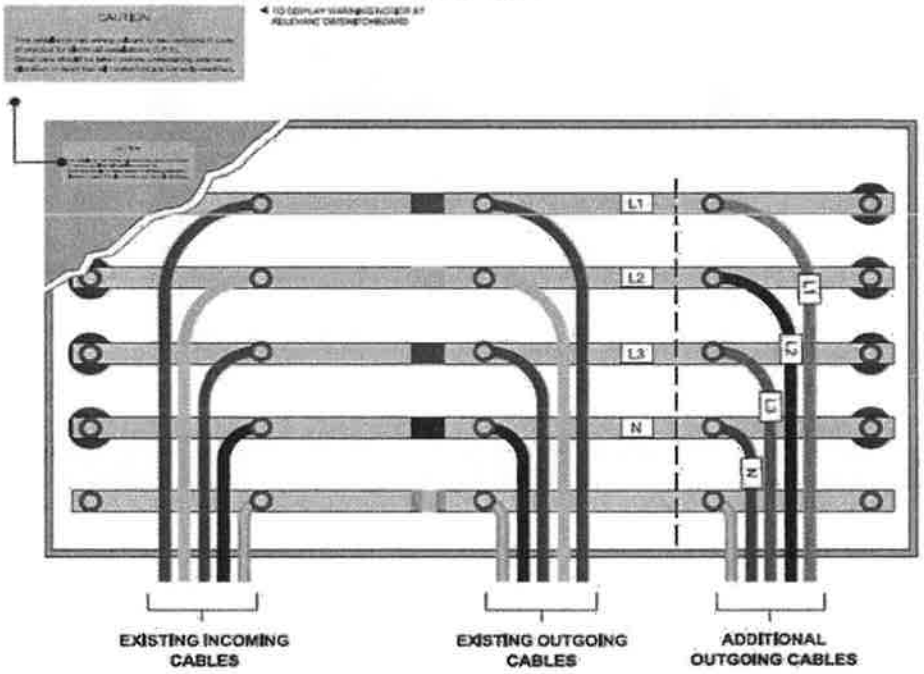


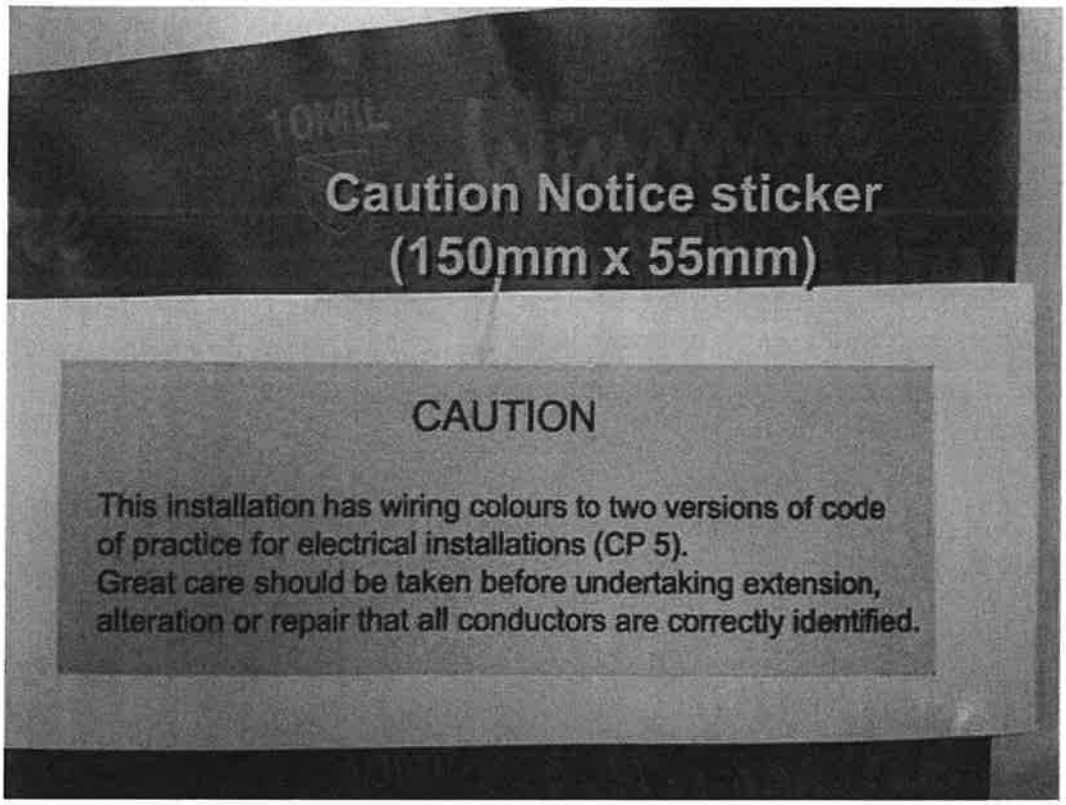


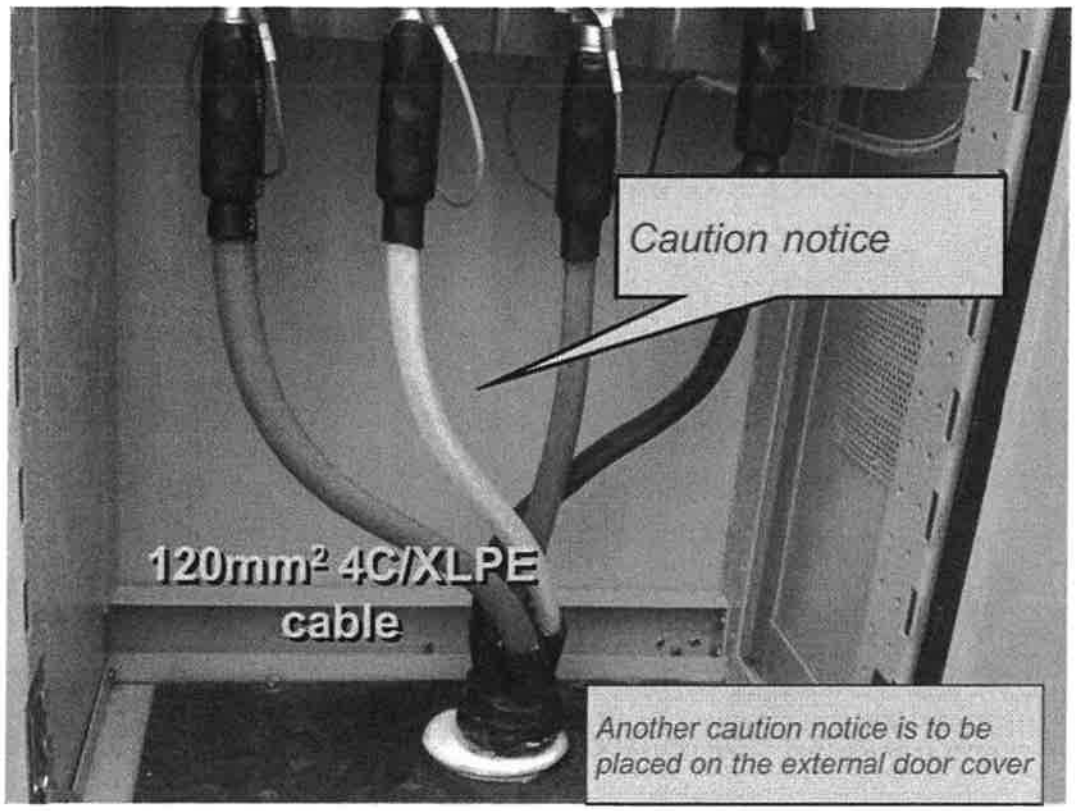
To provide sufficient space for the termination of service cable and ensure correct positioning of the wires

3. Addition of Outgoing Cables to Existing Consumer's Switchboard

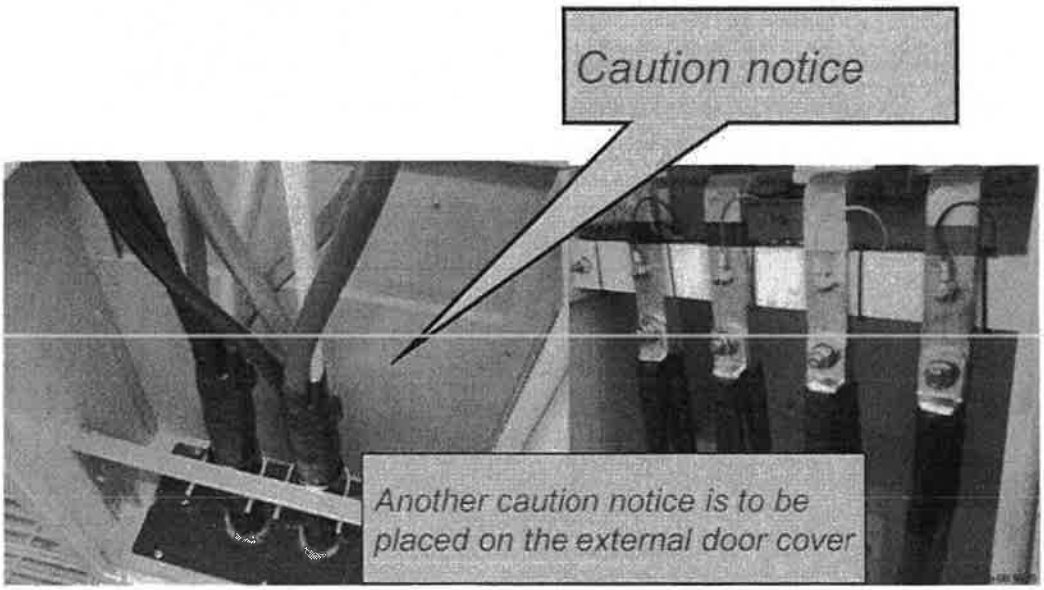
Busbar compartment of a LVB – simple illustration



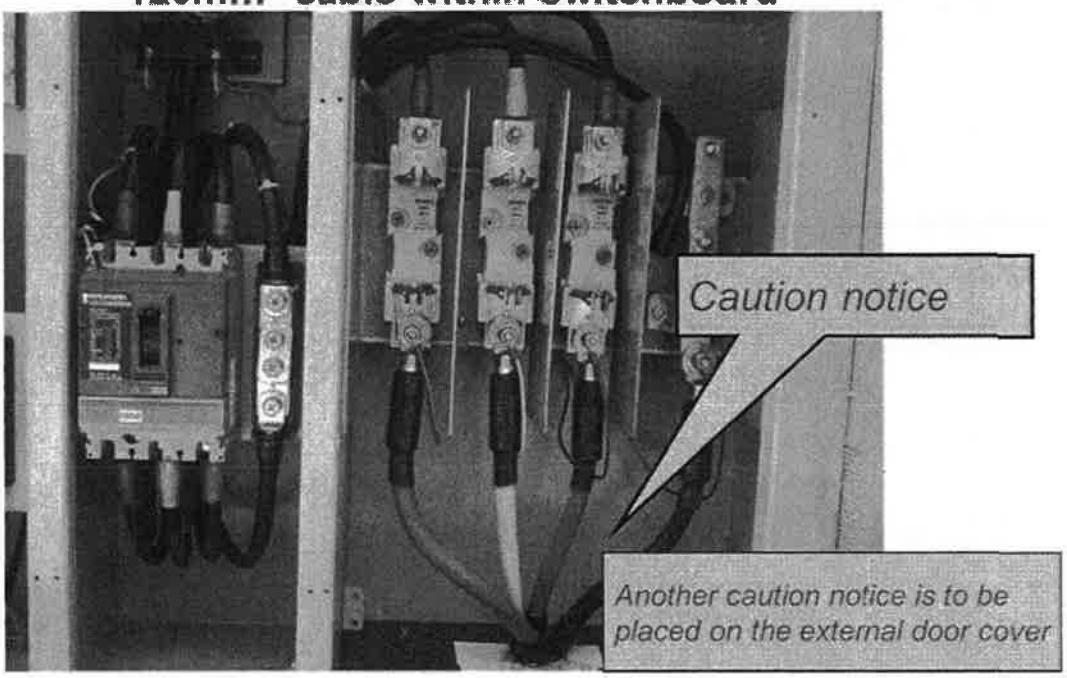

Caution Notice sticker
(150mm x 55mm)
CAUTION
This installation has wiring colours to two versions of code of practice for electrical installations (CP 5).
Great care should be taken before undertaking extension, alteration or repair that all conductors are correctly identified.

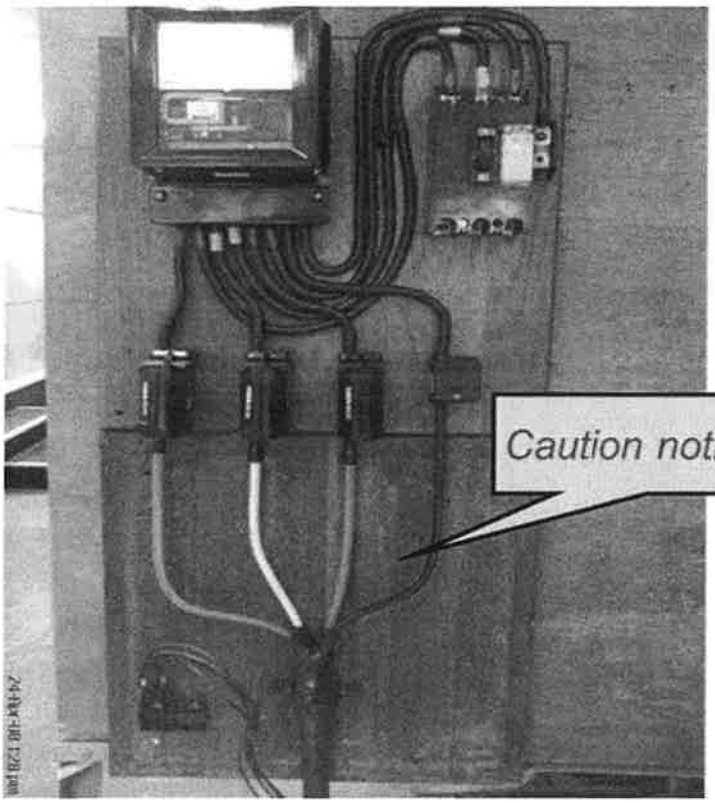

Caution notice
120mm² 4C/XLPE cable
Another caution notice is to be placed on the external door cover

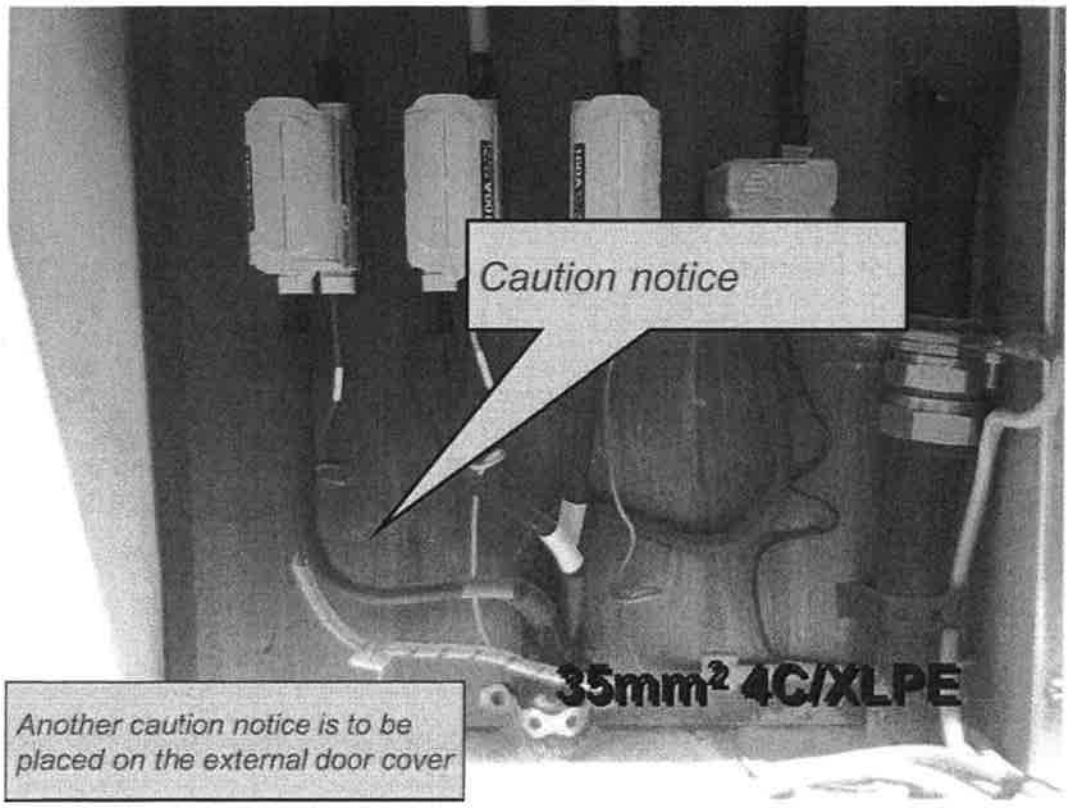
2 X 300mm² 4C/XLPE cables

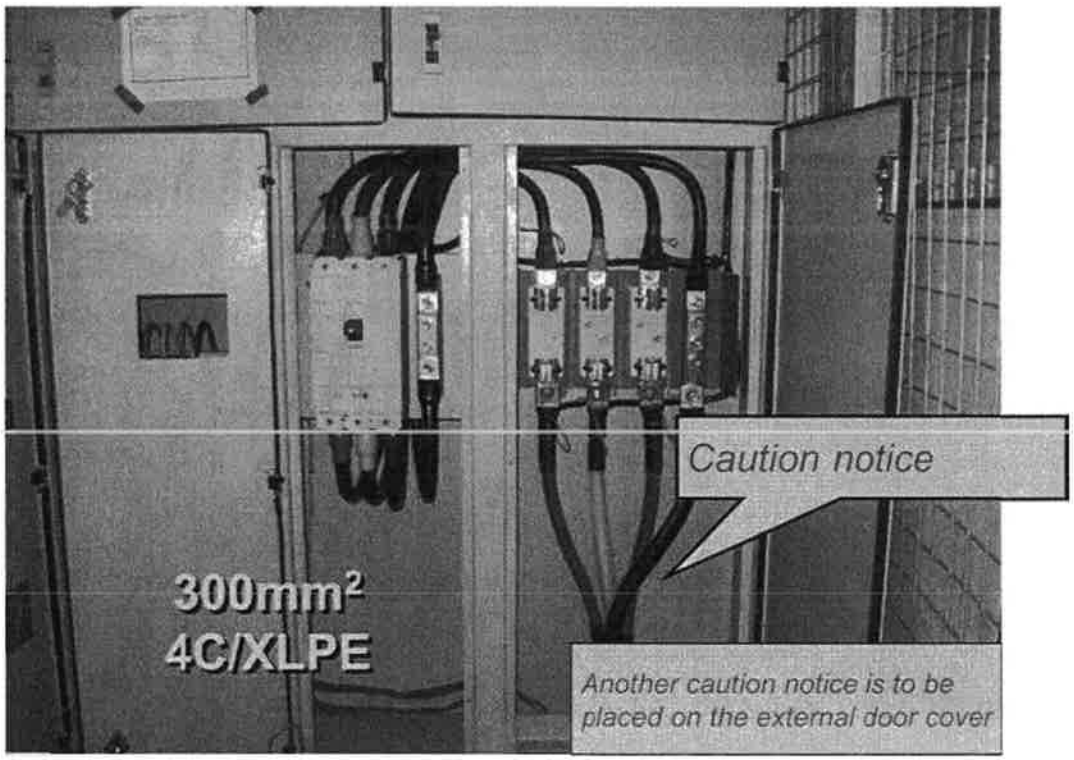


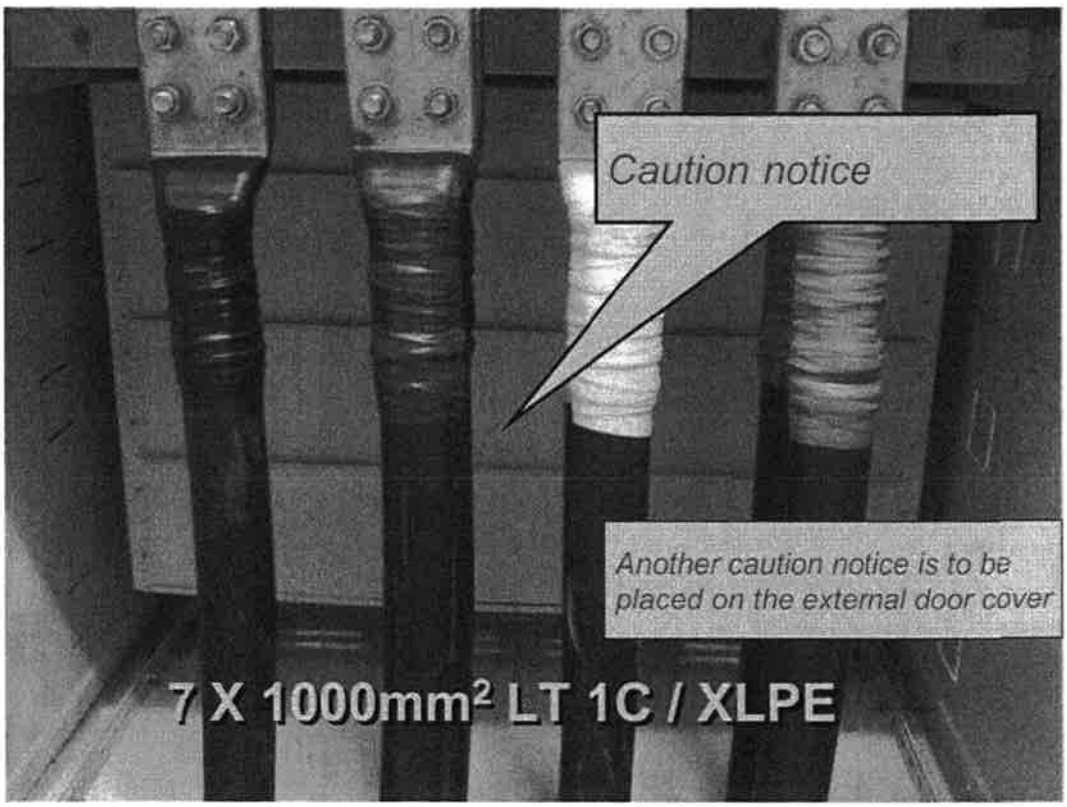
120mm² cable within switchboard




35mm²
4C/XLPE
Caution notice


Caution notice
35mm² 4C/XLPE
Another caution notice is to be placed on the external door cover


Caution notice
300mm²
4C/XLPE
Another caution notice is to be placed on the external door cover


Caution notice
Another caution notice is to be placed on the external door cover
7 X 1000mm² LT 1C / XLPE

4. Handbook on Site Requirements - relating to Substation Building

Requirements relating to substation building can be found in:

http://www.singaporepower.com.sg/irj/go/km/docs//wpccontent/Sites/SP%20PowerGrid/Site%20Content/Resources/documents/substationsamplephotohandbook.pdf

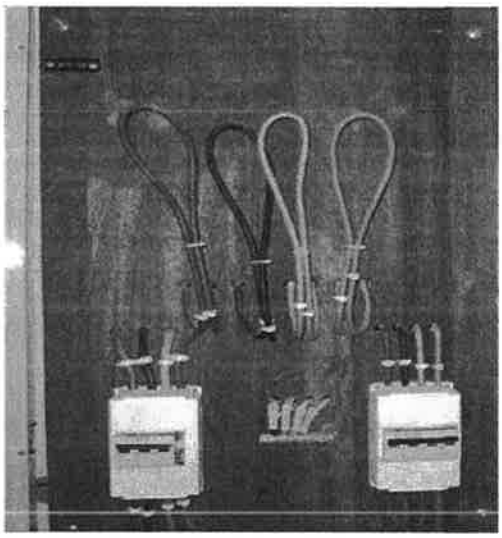
TOPIC 4c - METERING REQUIREMENTS

1 General Requirements

- Meter panel/board and ancillaries must be ready at site before Meters Section installs meter.
- At least 4 business days lead-time must be given for request to install meter.
- Lockable meter enclosure must be fitted with the master series lockset (Union G1HBG, Yale MK48 or Abloy MK911047).
- The height of the meter register must be between 1.0m and 1.8m above ground level.
- Submit application for upgrading, downgrading, replacement, relocation of switchboard.
- No payment is required for normal meter installation. For other metering services where payment applies, it shall be made payable to "SP PowerAssets Ltd" by crossed cheque at Electrical Meters Section.

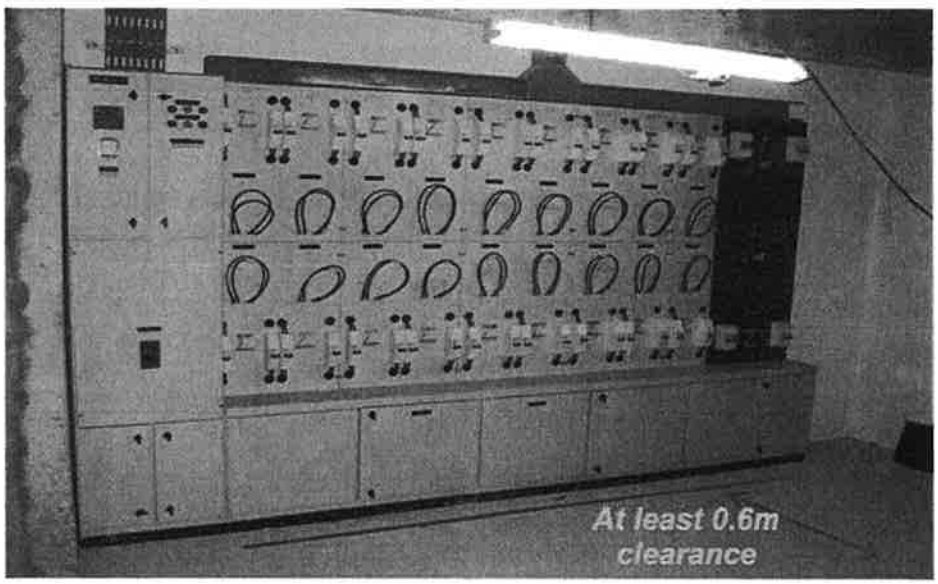
2 Whole Current Meter Installation

- Provide pre-wired meter board of appropriate size to mount a 3 phase meter, MCBs and other ancillaries.
- Meter board shall be securely fixed with at least 4 screws/bolts.
- House number shall be permanently labeled on the meter board. It can be either engraved on plastic or metal material and firmly screwed or riveted to solid wall or door.
- The clearance from the surface of the meter board to the access opening shall be at least 200mm.



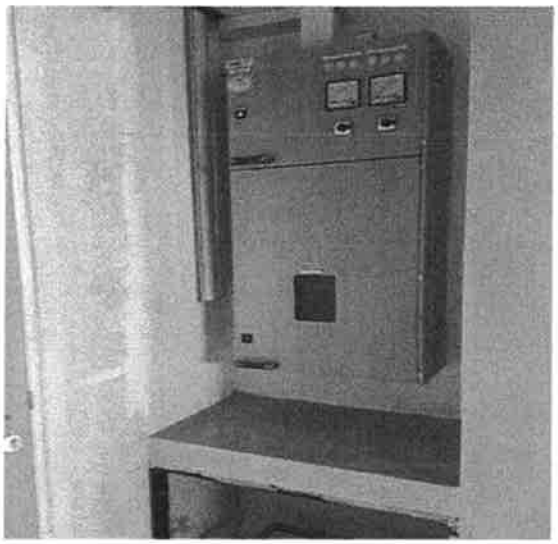
3 Centralised Meter Room

- Access door should be at least 600mm (W) x 2100mm (H).
- At least 2000mm standing height.
- At least 700mm space in front of meter panel (free standing meter panel, At least 700mm space at side and back).
- Unit number to be permanently labeled on each meter board / box in a centralised meter room/riser.



4 Meter Compartment

- Unit number to be permanently labeled (engraved/embossed on metal/plastic material) and riveted / screwed on mounting surface.
- Depth of meter compartment must be between 200mm to 300mm from meter board surface to compartment door access.
- Ensure that the meter compartment is isolated from water / gas compartment.





5 Meter Compartment at Gate Pillar

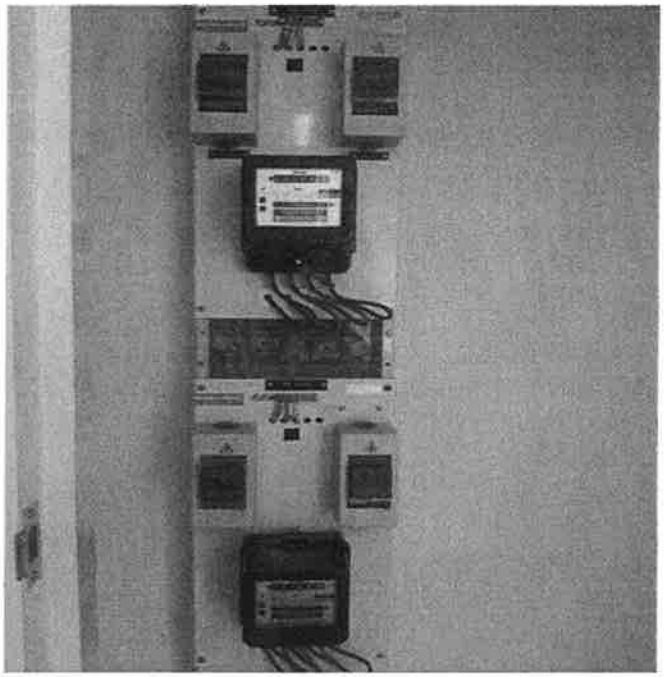
- Provide standing space of 700mm in front of the gate pillar.
- Provide suitable concrete platform or hinged galvanized steel grating over the drain in front of the gate pillar.
- Provide hinged door with a clear glass-viewing window of 200mm (W) x 300mm (H) x 6mm (thickness) directly in front of the meter position.
- Weatherproof compartment with sufficient ventilation.
- Door opening shall have at least 450mm width clearance.





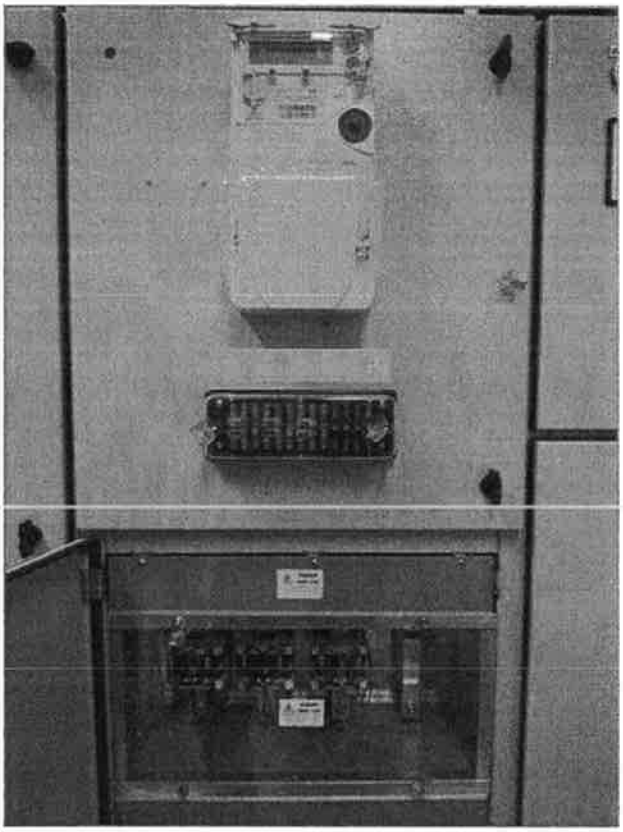
6 Meter Riser

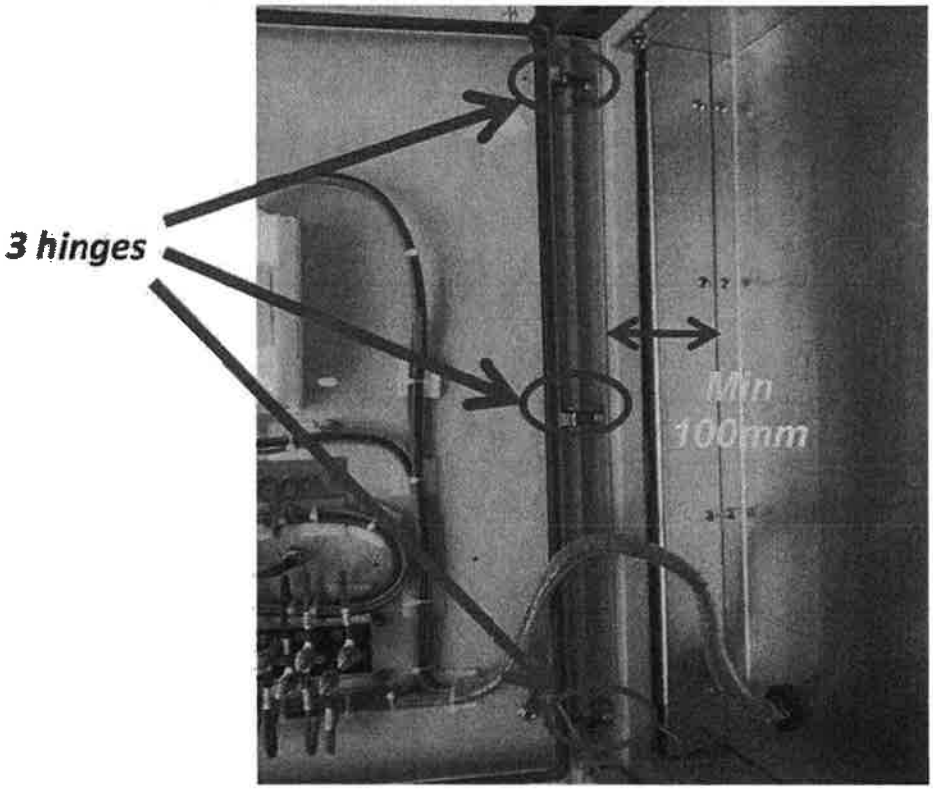
- Access door to the meter riser should be at least 500mm in width.
- Depth of the meter board to the riser door access should be at least 200mm.
- Ensure that the height of the meter is between 800mm to 1800mm from the standing ground level.
- Provide the recommended master series lockset if the access door is to be locked.

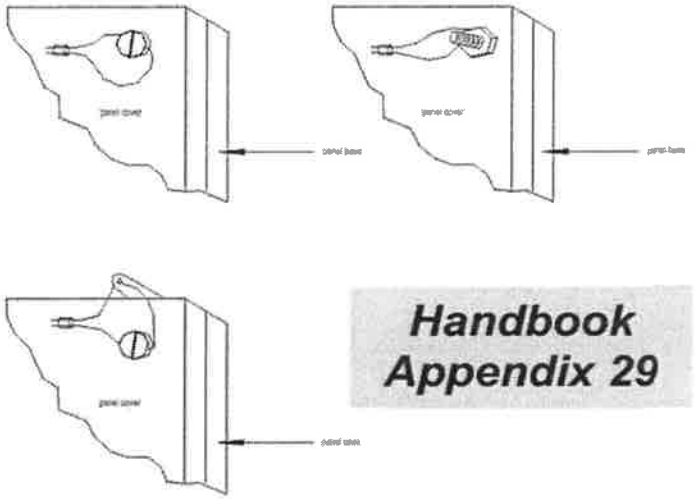


7 Low Tension CT-Operated Meter Installation

- Provide 4-pole 6A MCB. Pilot Lights not required
- The top of the meter panel shall not exceed 2.0m from the ground.
- The panel shall be of 3 hinges and able to swing open out at least 90°.
- The depth of the panel shall be 100mm from the cover to the base.
- Facilities for sealing shall be provided.
- Consumer shall provide 3 nos. of metering current transformers (CTs) of 5VA, accuracy class 0.5 and complying with IEC 60044-1.
- Contractor shall be present to install CTs on the day of meter fixing.

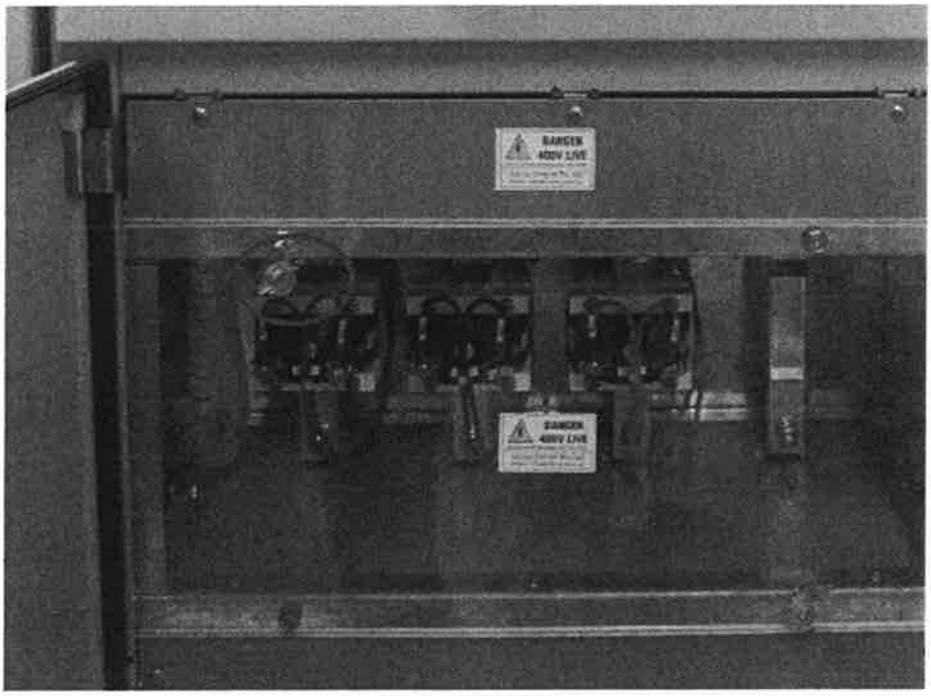



3 hinges
Min
100mm



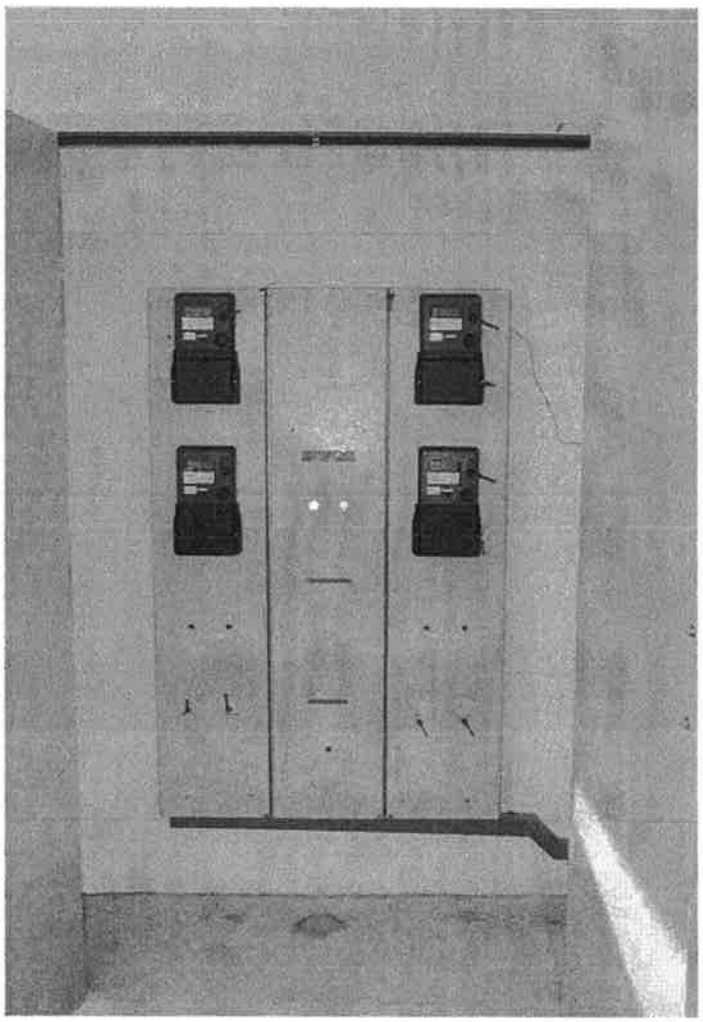
Handbook Appendix 29

All holes for threading seal wires should be 2 mm size



8 High Tension Metering

- Provide pre-wired meter panel.
- HT meter kiosk door fitted with master series lockset (Union G1HBG, Yale MK48 or Abloy MK911047).
- Provide and maintain functional telephone line.
- Provide adequate lighting and 2-ganged 13A SSO.
- Cover all cable trunkings and fasten with screw.
- Complete all outstanding works inside HT meter kiosk before meter installation. Example painting, seal all openings, lighting, power and telephone point.



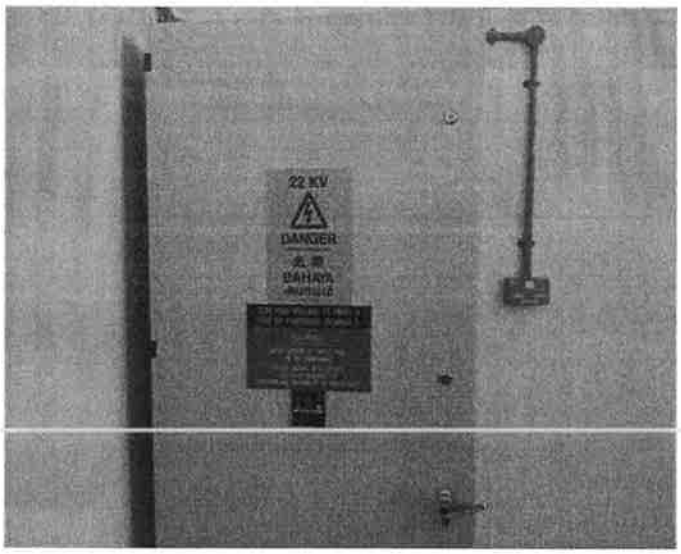
- Table shows the specifications of metering CT and VT for 22kV (and below) and 66kV (and above).

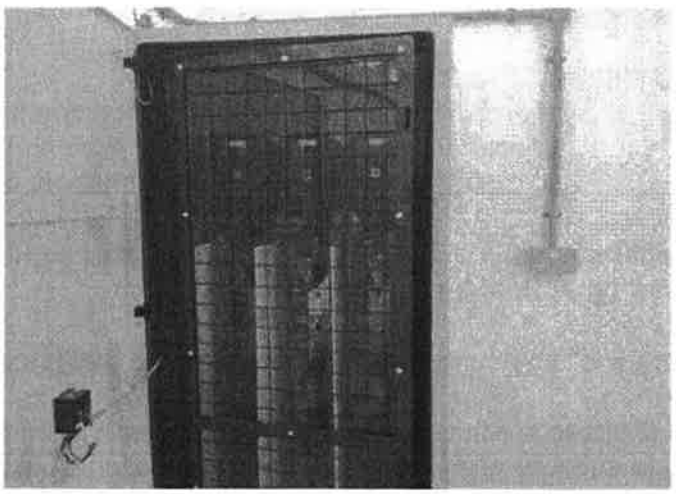
	22kV and below		66kV and above	
	CT	**VT**	**CT**	**VT**
Class	0.5	1.0	0.5	1.0
Burden (VA)	15	100	30	100
Secondary Rating	5A	110V	5A	110V
IEC Testing Standard	60044-1	60044-2	60044-1	60044-2

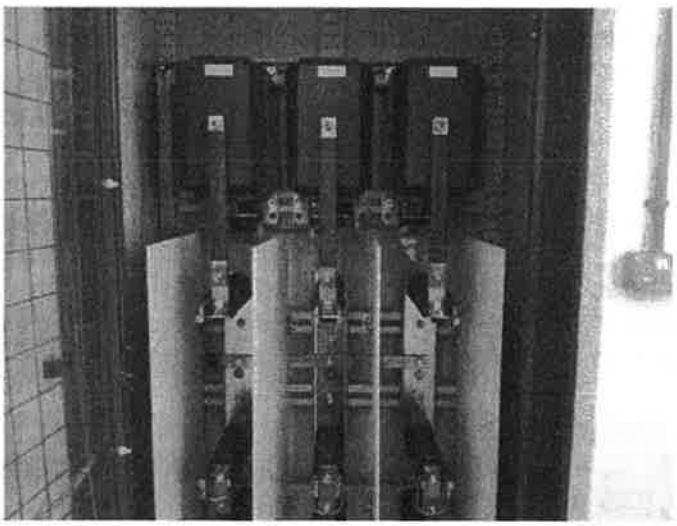
(Taken from Metering code August 2009)

- All metering CT and VT terminals must be sealable.
- Submit CT / VT Test reports online.
    - Test report issued by a laboratory accredited for testing and certification by SAC-SINGLAS or from a manufacturer with a test certificate endorsed by a national accredited laboratory.
- Provide appropriate metering transformers and send to Meters section for testing at least 2 weeks prior to installation.
- Arrange for inspection of meter kiosk before meter installation.
- The licensed electrical engineer shall ensure the enclosure for housing PTs is suitable and offers adequate protection at its operating voltage level.
- The licensed electrical engineer shall also ensure that VT cables for external VT enclosure are rated according to the operating voltage level.
- The VT cables shall be labeled L1, L2 and L3 or colour coded along the cables to facilitate identification.
- The rated short-time current rating for the current transformer must not be less than 40kA 3 seconds, 25kA 3 seconds and 20kA 3 seconds for connection at 66kV, 22kV and 6.6kV respectively.
- VT shall be one unit 3-phase or 3 units single phase 66kV/110V, 22kV/110V or 6.6kV/110V voltage transformer of accuracy class 1.0 and 100VA burden per phase, connected star-star.

9 External VT Enclosure Example

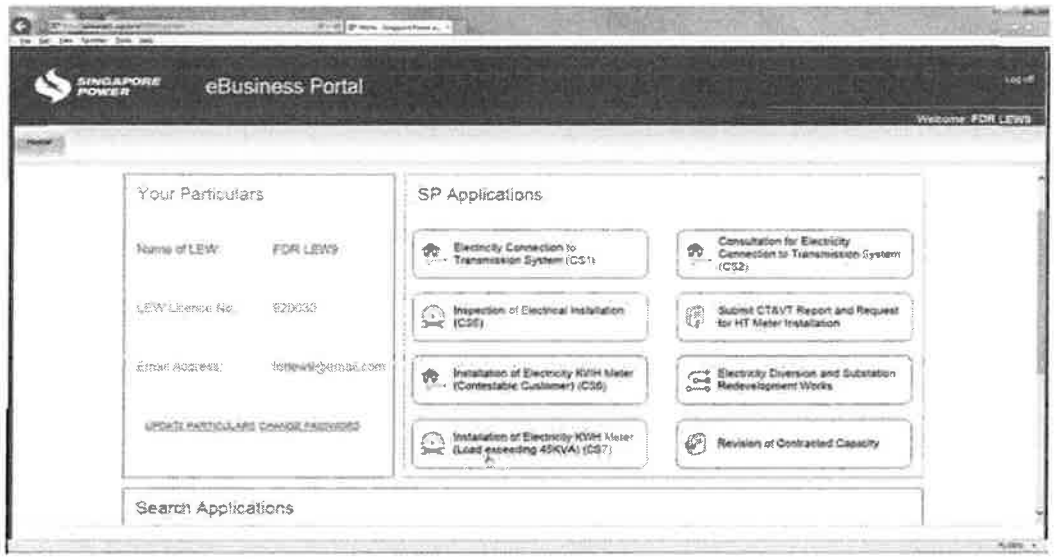






10 Online Submission of CT/VT Reports

- Login to SP eBusiness Portal, https://ebiz.singaporepower.com.sg/irj/portal

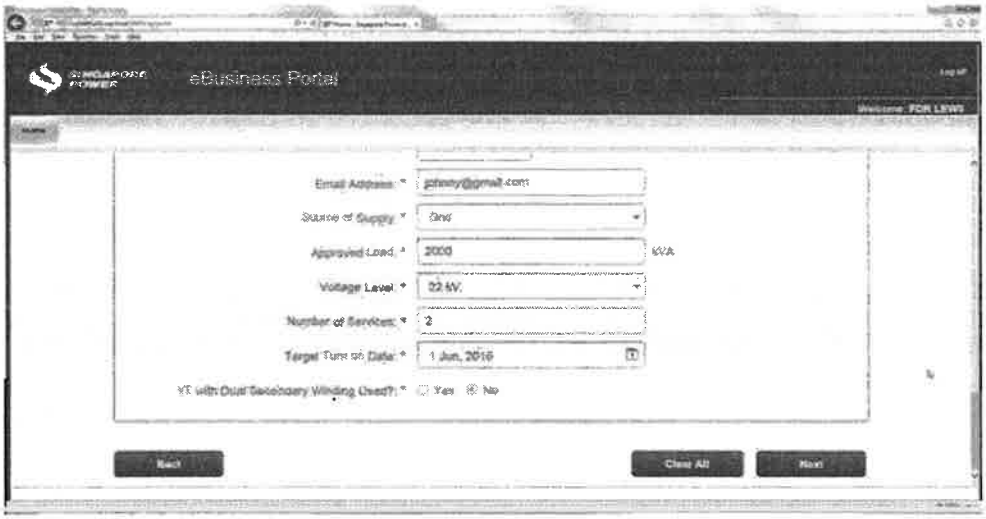


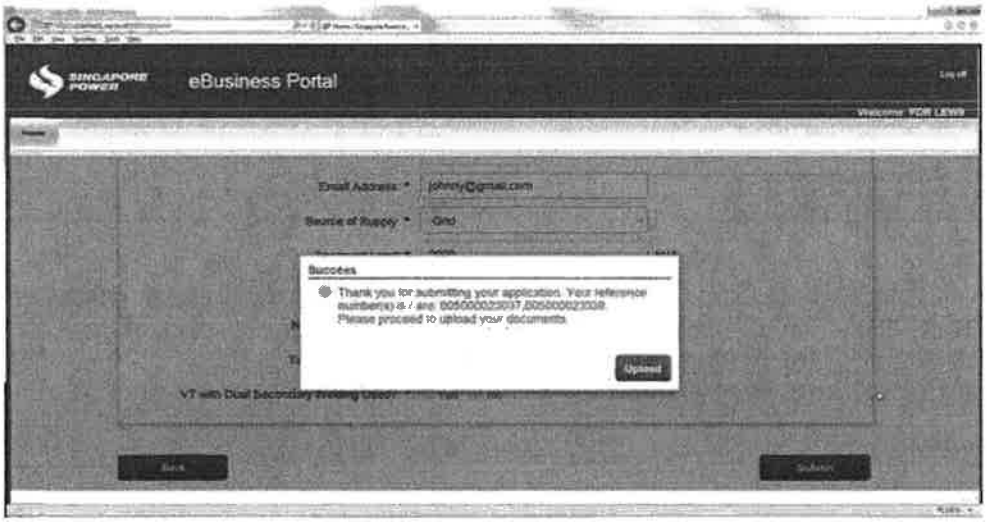
- Click on "Submit CT&VT Report and Request for HT Meter Installation.



- Key in application number if you were the LEW who had submitted the application.

- If you are not the LEW who submitted the application, you need to fill in the project details manually.



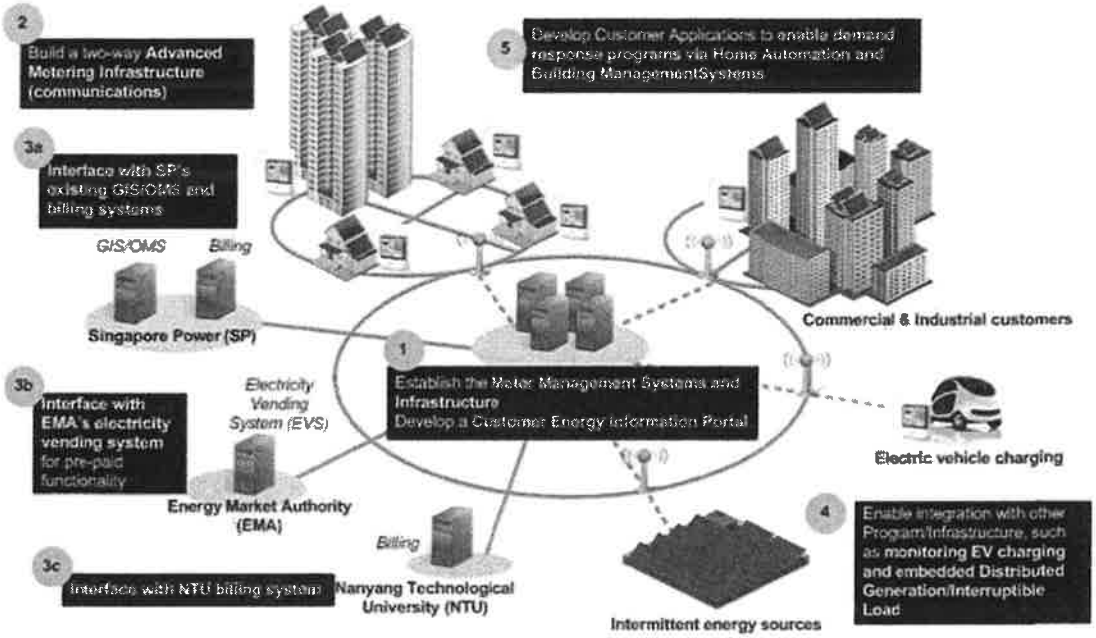


- Attach all the documents in the list.



11 Advanced Metering Infrastructure (AMI)

- Intelligent communications interconnects various smart grid technologies, which are centrally managed.



12 Final Remarks

"DO"

- Do ensure that metering requirements are fulfilled before meter installation.
- Do check wirings to ensure that they are not transposed.
- Do ensure meter is wired to the correct address.
- Do report to Meters Section at 6876 4848 / 4849 immediately if there is any missing seal.

"Don't"

- Don't place any obstruction to the meter panel opening.
- Don't just break any metering seal without first informing Meters section.
- Don't just put temporary labeling on the meter board.
- Don't use meter compartment (riser) as storage space.

Useful URL for Handbook:

http://www.singaporepower.com.sg/irj/go/km/docs//wpccontent/Sites/SP%20PowerGrid/Site%20Content/Resources/documents/howtoapplyforelectconn.pdf

TOPIC 5: COMMON NON-COMPLIANCES IN ELECTRICAL INSTALLATION

1 Introduction

The consumer's electrical installation begins at the outgoing terminals of the electricity supplier's meter. The electricity supply to the dwelling is subject to the statutory requirements of the Electricity Act (chapter 89A) and Electricity (Electrical Installations) Regulations.

The fundamental reason for inspecting and testing an electrical installation is to determine whether new installation work is safe to be put into service. Inspection always precedes testing and dead tests always precede live tests.

Even the most experiences LEWs can be expected to make the occasional mistake when carrying out electrical installation work. This is one of the main reason why every new electrical installation and every alteration and addition to an existing installation, must be thoroughly inspected and tested, and defects or omissions found made good, before they are put into service.

The aim of this chapter is to promote good practice by providing LEWs with practical advice and guidance which answers many of the questions commonly arising during the inspection and testing of electrical installation work.

2 New Electricity Market (NEM)

In NEM, EMA has re-categorized the common non-compliances into three groups

Category 1 -- Serious
Category 2 -- Minor and
Category 3 – Operational

EMA is monitoring the common non-compliances in category 1 & 2 only. A proper penalty will be given to these two categories. For category 3, no penalty is imposed by EMA. However, SP Services or SP PowerGrid may not allow the supply to be turned-on.

No electricity supply shall be taken from a supply line until every electrical installation connected to such supply line has been inspected and certified fit by a licensed electrical worker; and where the installation is exempted from licensing, it shall be checked by the Market Support Services Licensee.

If the inspection failed, LEW is to check the installation thoroughly, rectify all defects and apply for another appointment. A fee per account is chargeable for each subsequent inspection.

3 Non-Compliances of SS CP5: 1998 and Other Relevant Regulations

The non-compliances are grouped into three separate categories depending upon the severity of the defect

3.1 CATEGORY 1

Non-compliances that pose immediate safety hazards or are of a serious nature

1001 No protection against direct contact for live conductors.
1002 Wrong polarity / phase sequence.
1003 Using single-pole circuit breaker for neutral conductor
1004 Using unacceptable or deceptive method for earthing system / earthing system not provided.
1005 No provision of residual current circuit breaker (RCCB) of 30 mA sensitivity for domestic SSO / lighting circuits.
1006 No provision of residual current circuit breaker (RCCB) of 30 mA sensitivity for market / food stall, etc.
1007 No provision of residual current circuit breaker (RCCB) of 30 mA sensitivity for socket-outlet assembly used at construction site.
1008 No provision of residual current circuit breaker (RCCB) of 30 mA sensitivity for general-purpose SSO circuit outdoor.
1009 Neutral of generating set not effectively connected to Earth.

3.2 CATEGORY 2

Non-compliances that may pose safety hazards

General

2101 Insulation resistance value less than 0.5 MΩ for low voltage circuit.
2102 No documentation on tests carried out / incomplete test reports.
2103 Single-line drawing not provided / updated / endorsed by LEW.
2104 No provision of safety related equipment or signs such as rubber mat / fire extinguisher / danger sign / CPR chart at main intake switchboard.
2105 Improper installation of reduced voltage or SELV system.
2106 Improper installation that poses electrical safety hazards to the public. (to specify)
2107 Improper installation of generating sets.

Switchboard / DB / Control of Circuits

2201 Switchboard or distribution board not readily accessible.
2202 Circuit breaker before / after meter not of appropriate type.
2203 Circuit breaker of insufficient short circuit capacity.
2204 Improper interconnection of sources of supply.
2205 Failure to provide DP isolator / circuit breaker at meterboard or incoming of DB.
2206 Fittings or final circuits in defined area supplied from different sources of supply.
2207 Non-weatherproof distribution board located below water or drainage pipe joint or valve.
2208 Circuit breaker overrated for protection of a circuit.
2209 Additional point(s) sharing air-con or water heater final circuit.

Earthing

2301 Earthing system inadequately / improperly installed.
2302 Improper or no earth electrode inspection chamber.
2303 Earth fault loop impedance is high for TN-S system or the product of Rala exceeds 50 volts for TT system.
2304 Circuit protective conductor (CPC) not provided or sharing of CPC in final circuits.
2305 Earthing conductor / CPC / bonding conductor undersized.
2306 Using green & yellow colour combination wire as live conductor / wrong colour coding for protective conductor.
2307 Main equipotential bonding not provided for main water pipe, gas pipe or exposed metallic part of building structure.
2308 Exposed conductive parts not bonded to Earth.

Equipment / SSO

2401 Circuit breaker / isolator / RCCB / switch / ceiling rose / connection unit underrated.
2402 Switch or SSO in enclosed space susceptible to risk of fire or explosion.
2403 No provision of residual current circuit breaker (RCCB) for SSO in non-domestic electrical installation.
2404 Non weatherproof electrical device(s) exposed to weather or water splashing.
2405 Non weatherproof electrical equipment installed under tents in outdoor conditions.
2406 SSO installed at less than 150 mm above working surface or floor level.
2407 SSO installed on floor without mechanical protection or protection against ingress of water.
2408 Switch controlling SSO for general purpose not readily accessible.
2409 Using electrical accessory/fitting not complying standards stipulated in the code of practice CP 5 or CP 88.

2410 Socket-outlets (SSO) / switches installed inside bathroom.

Cable / Wiring

2501 Mains / sub-mains / busbar / final circuit undersized.
2502 Cables laid underground without armour or metallic sheath; non-sheathed cable installed in underground pipe.
2503 Cable installed not suitable for the environment or weather conditions.
2504 Single PVC-insulated cable installed without conduit or trunking.
2505 Wiring above false ceiling not properly installed or installed without mechanical protection.
2506 Cable in same conduit / trunking / ducting with other services.
2507 More than one final circuit in one circuit breaker way.
2508 Cable armour improperly bonded or not bonded to Earth.
2509 No provision of PVC or rubber grommet / bushing at metallic sharp edges to prevent damage of cable insulation.
2510 Electrical connections / joints not mechanically and / or electrically sound.
2511 Wiring encroached into other premises / another electrical installation.

3.3 CATEGORY 3

Non-technical issue

3001 Licensed electrical worker absent.
3002 Gate/door locked.
3003 Work incomplete.
3004 No incoming electricity supply.
3005 Meter board/meter compartment at gatepost not complying with requirements.
3006 Incorrect address.
3007 Premises not fully accessible for inspection of electrical wiring installation.
3008 Wrong type of application.
3009 No Statement of turn-on.

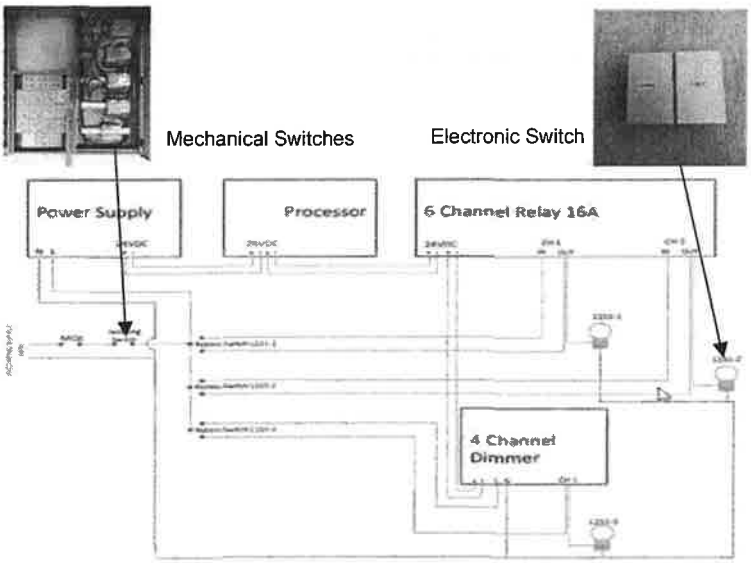
3.4 ABBREVIATIONS

CPC	Circuit Protective Conductor
mA	Milliampere
M-ohm	1,000,000 ohm
RCCB	Residual Current Circuit Breaker
DP	Double Poles
SSO	Switched Socket Outlet
PVC	Polyvinyl Chloride

4 Detailed Description of Common Non-Compliances on Site

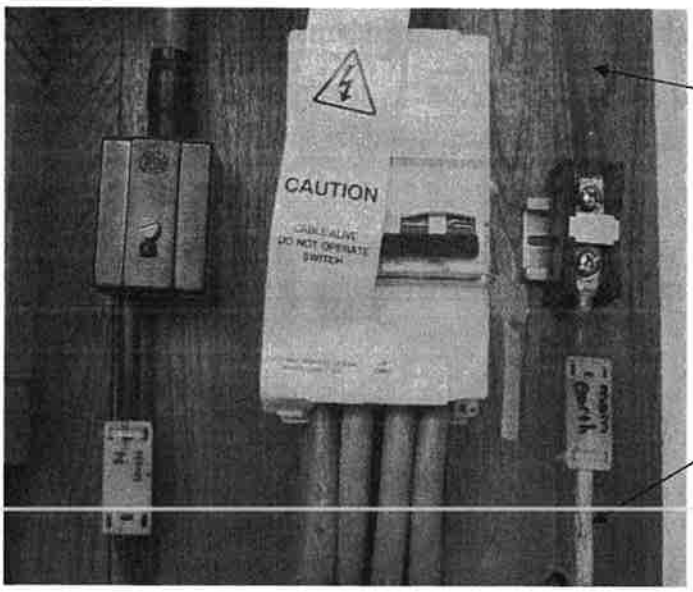
4.1 Electronic Switch Controlled Remotely

Electronic switches without a mechanical switch in the main circuit do not provide a full off-state. Therefore, the circuit on the load side should be considered to be live.



4.2 Identification of Protective Conductor without Using the Colour Combination of Green and Yellow or Using Single Colour Green

For example, in a final circuit, when a single core black colour PVC-insulated/PVC sheathed or XLPE-insulated/PVC sheathed cable is used as a circuit protective conductor. The application at terminations of tapes, sleeve or discs with the combination colours of green and yellow is acceptable.

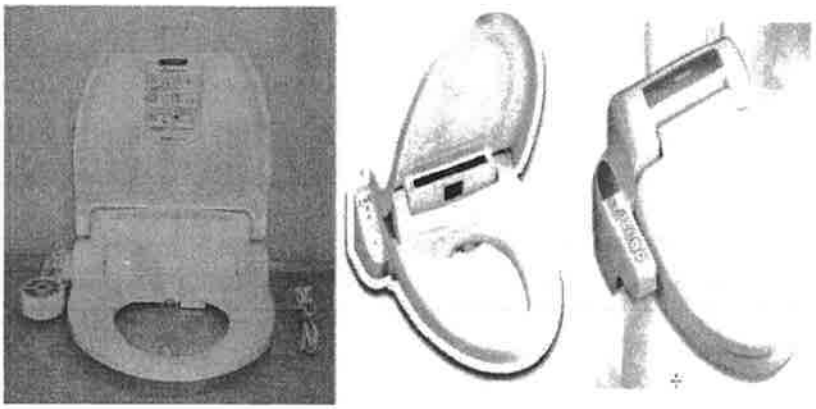


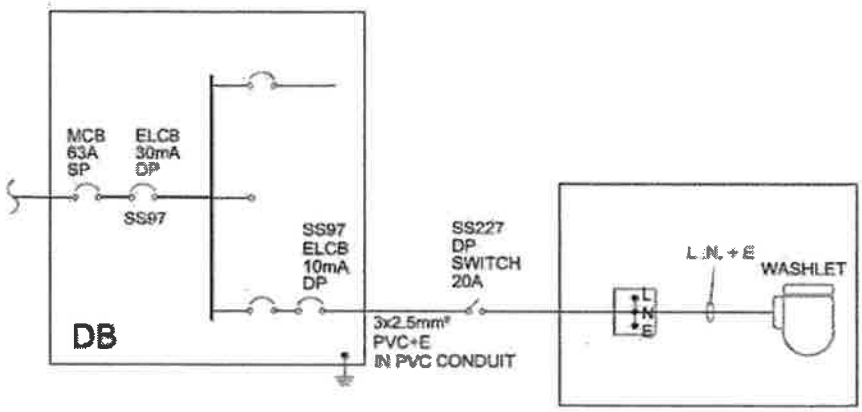
The single colour green shall not be used

One of the colours shall cover at least 30% and at most 70% of the surface

4.3 Electrical Installation Requirements For Washlet

The equipment shall be controlled by a 20 A double pole switch and protected by an earth residual current circuit breaker (RCCB) of 16 A rated current and l0 mA tripping sensitivity.

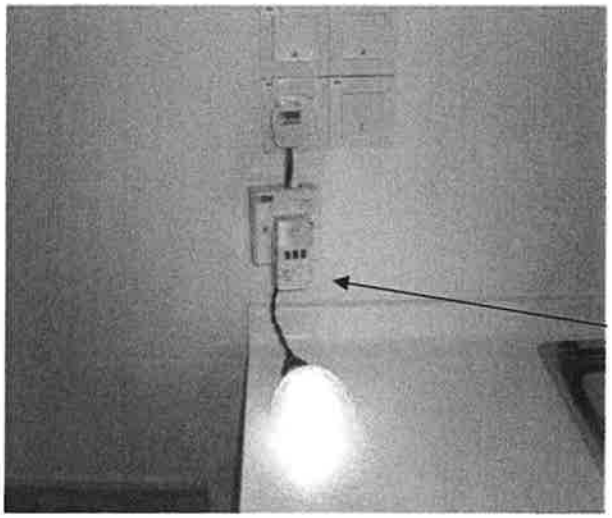




4.4 Wrong Polarity

For example, wrong polarity at the junction box which is used for the final connection to storage water-heater or instantaneous water-heater. The phase conductor is connected to the earth-terminal of the junction box.

For example, wrong polarity at the socket-outlet such as transposition of the phase and neutral conductors or the phase conductor is connected to the earth-terminal.



Checker Plug is used for checking the polarity

4.5 Exposed Conductive Parts Not Connected to Earth Effectively

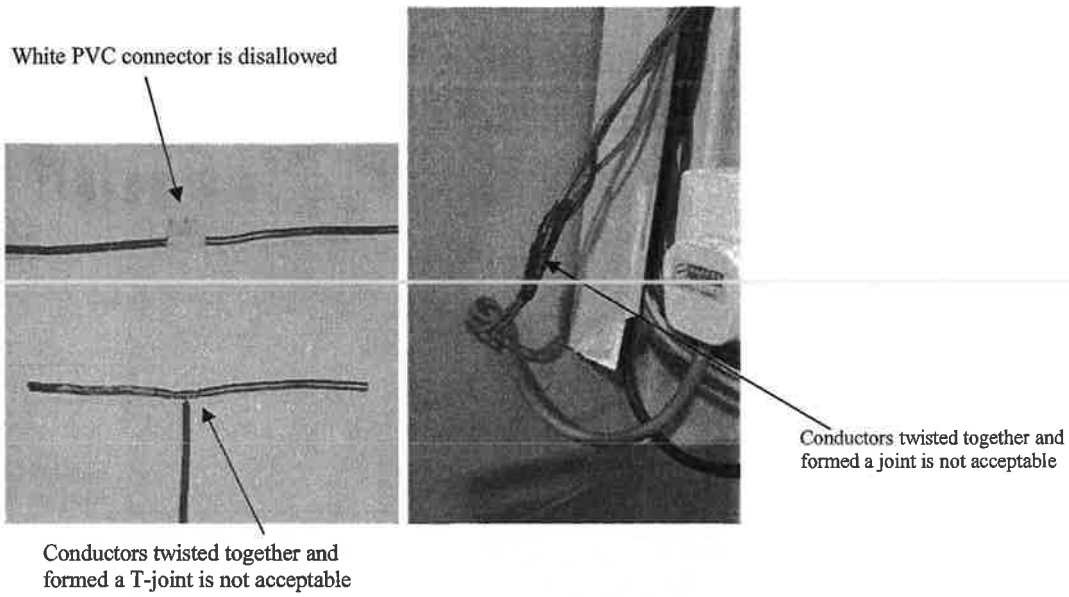
These include the metallic enclosures of Class 1 current-using equipment, metallic cable sheaths, cable trays, trunkings and metallic conduits etc.



Earthed extraneous conductive part

4.6 Electrical Connection / Joint Not Properly done

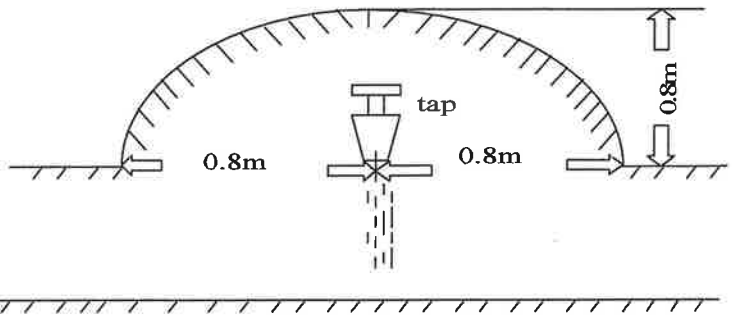
For example, PVC-cable is jointed to another PVC-cable by twisting the conductor together and covered the joint with PVC-tape.



4.7 Non Weatherproof Electrical Device Exposed to Weather or Water Splashing

For example, wall mounted junction box or lighting fitting mounted on the wall above the bath tub. A person standing in the wet bath-tub can touch the exposed metallic part of the light fitting or junction-box. Also, water could be sprayed on these devices when using the shower.

Acceptable distance between switch/socket outlet from water tap.



Note:

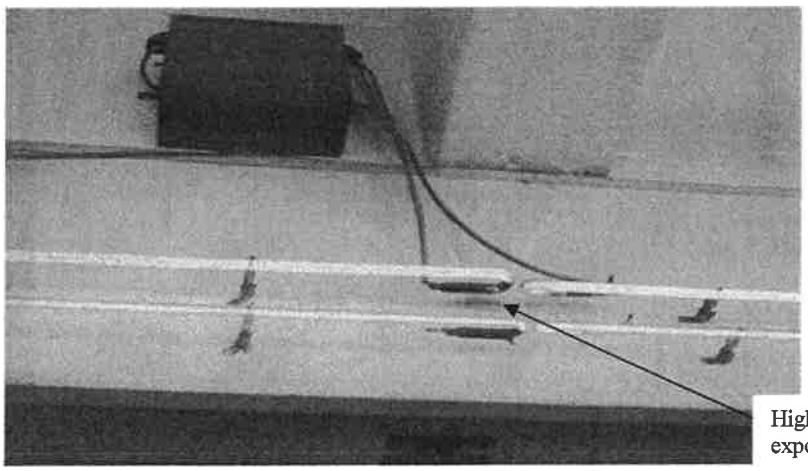
1. Switch/SSO shall be installed above the water tap source and outside the 0.8m zone to prevent water splashing.

2. Switch/SSO installed above the water tap source but less than 0.8m away from it shall be provided with a splash-proof cover to protect against water splashing.

3. Switch/SSO installed below any water tap source must be of weather-proof type.

4.8 Exposed Live Parts

For example, in high voltage discharge lighting installation, the joint of the high voltage conductor is exposed and not covered with suitable insulation. Furthermore, this joint can be touched by the person standing on the floor.

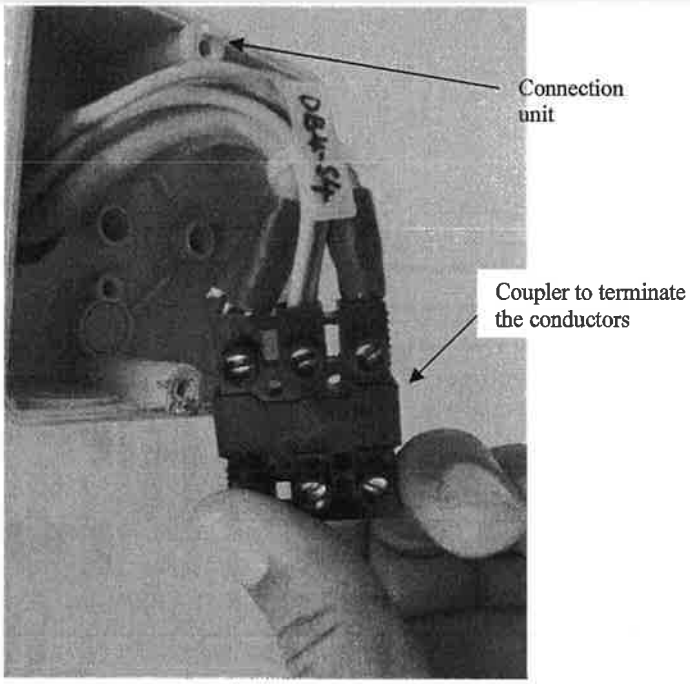


High voltage live joint exposed

4.9 Accessory Not Provided for the Lighting Point

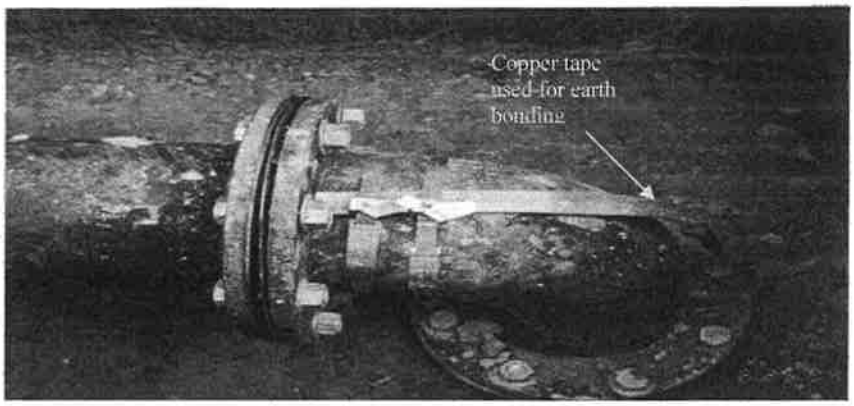
For example, using PVC insulated connector instead of the following accessories for the final connection of light fitting.

a) A ceiling rose to SS 23
b) A luminaire supporting coupler to BS 6972 or BS 7001.
c) A batten lampholder to SS 125 or SS 126.
d) A luminaire designed to be connected directly to the circuit wiring
e) A suitable socket outlet.
f) A connection unit to SS 241 or BS 1363 Part 4.



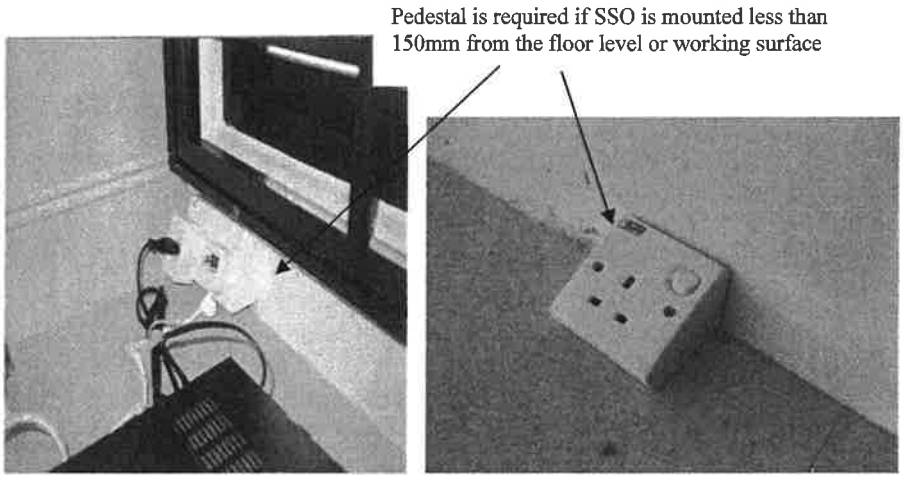
4.10 Main / Supplementary Equipotential Bonding Not Provided

Main equipotential bonding not provided for main water pipe, gas pipe or exposed metallic part of building structure.



4.11 SSO Installed at Less Than 150mm Above Floor Level or Working Surface

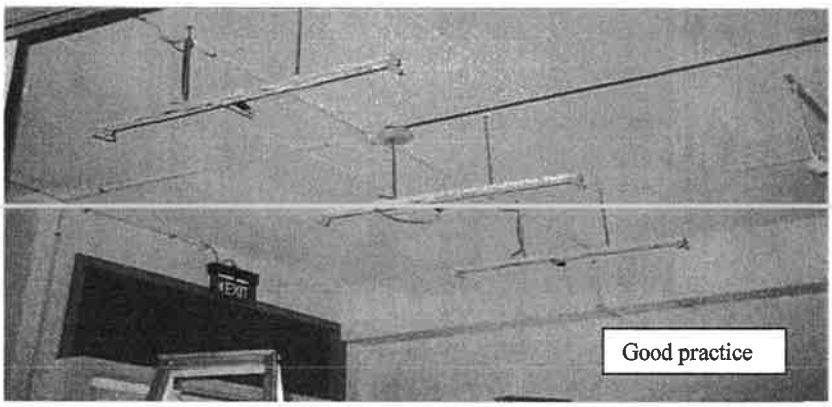
When a SSO is mounted on a wall, it is recommended that it should be mounted at a minimum height of 150mm from the floor level or 150mm above working surface. Also, when two SSO are installed side by side vertically, a distance of 150mm must be provided between the two SSO.

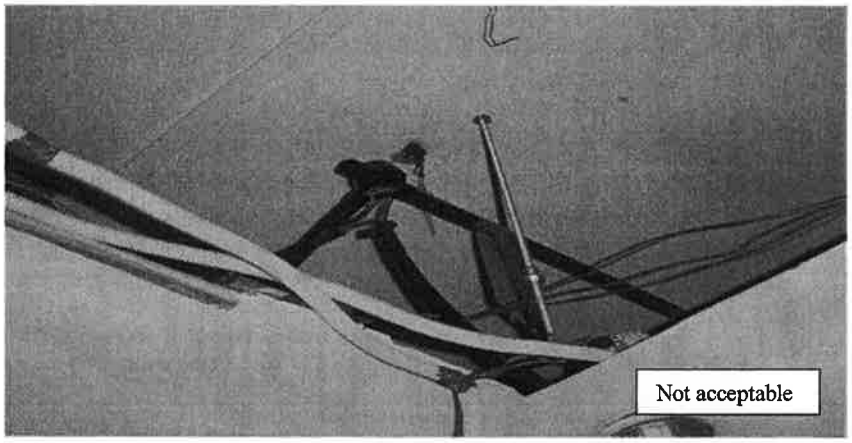


4.12 Wiring Above False Ceiling Not Properly Installed or Installed Without Mechanical Protection

For example, cable is laid on the false ceiling or,

For example, cable is laid in the conduit and hung in the air between two walls across the room.





4.13 Circuit Breaker Overrated for Protection of Circuit

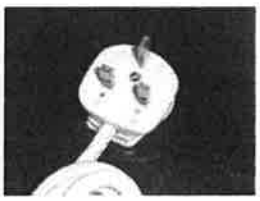
For example, a lighting circuit is protected by a 15A MCB but the light holder is rated at 2A.

4.14 Accessory Used without the Registration/Approval from Spring Singapore, Consumer Product Safety Department

- 4-gang lighting switch modified to 1 dimmer control and 3 lighting switch.
- Transformer for downlight not approved from Spring Singapore, Consumer Product Safety Department.

Following 14 items are to be Registered/Approved from Spring Singapore, Consumer Product Safety Department before use.

1) 3-pin rectangular type 13-Amp plugs
2) Fuses (less than or equal to 13-Amp) for use in plugs
3) 3-pin round type 15-Amp plugs
4) Multi-way adaptors
5) 3-pin portable socket-outlets
6) Portable cable reels
7) Instantaneous electric water heaters
8) Mains pressure electric storage water heaters
9) Residual current circuit breakers
10) 3-pin 13-amp socket outlets
11) 3-pin round type 15-Amp socket outlets
12) Domestic electric wall switches
13) Ballasts for tubular fluorescent lamps
14) Isolating transformers for downlight fittings



3-pin 13-Amp plugs



Fuses for use in plugs



3-pin 15-Amp plugs



Multi-way adaptors



3-pin portable socket-outlets



Portable cable reel



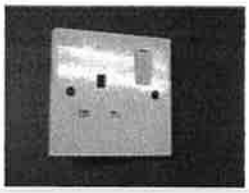
Instantaneous electric water heaters



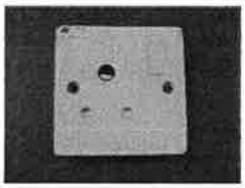
Mains pressure electric storage water heaters



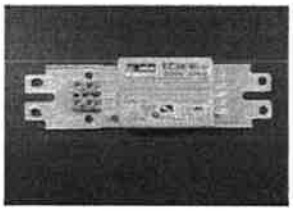
Residual current circuit breakers



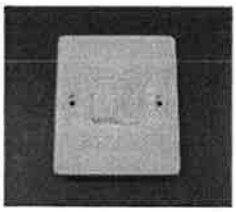
3-pin 13 –Amps socket outlet



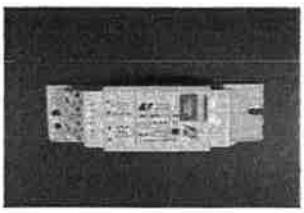
3-pin round type 15-Amp socket outlets



Ballasts for tubular fluorescent lamps



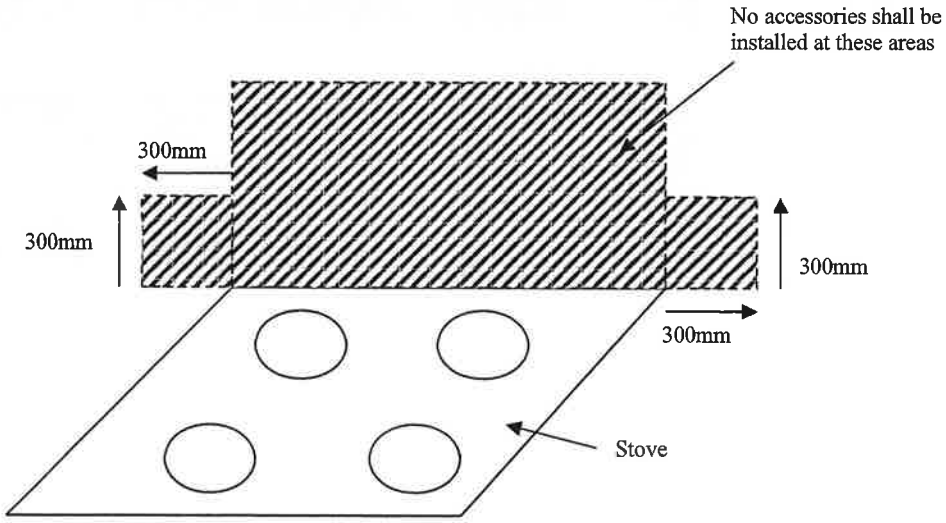
Domestic electric wall switch



Isolating transformers

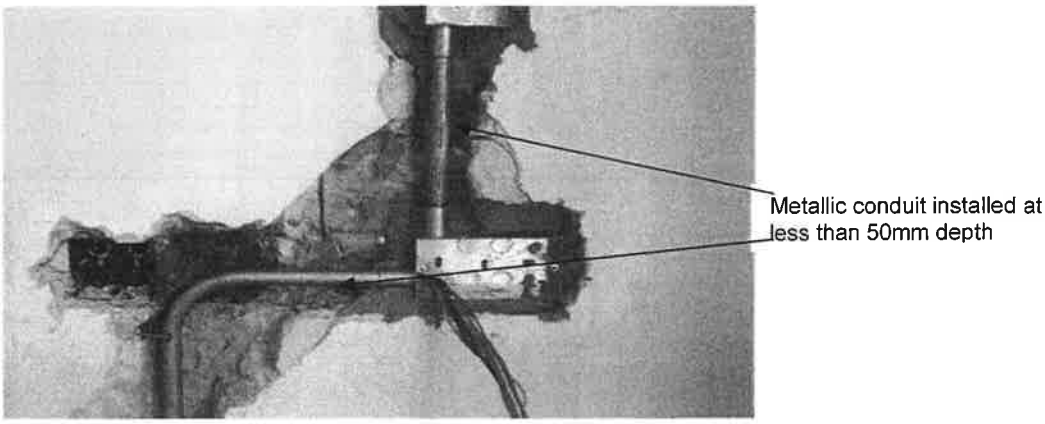
4.15 Non-proper protection against thermal effects

Fixed equipment which in normal operation has a surface temperature sufficient to cause a risk of fire or harmful effects shall have a sufficient distance from adjacent accessories.



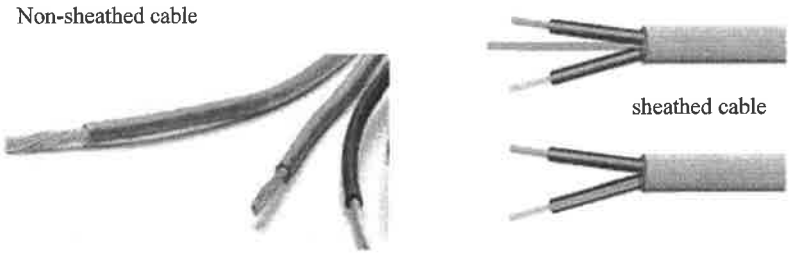
4.16 Concealed PVC cable installed at less than 50mm depth from the surface

Concealed PVC cable installed at a depth of less than 50mm from the surface shall be protected by a metallic conduit or trunking.



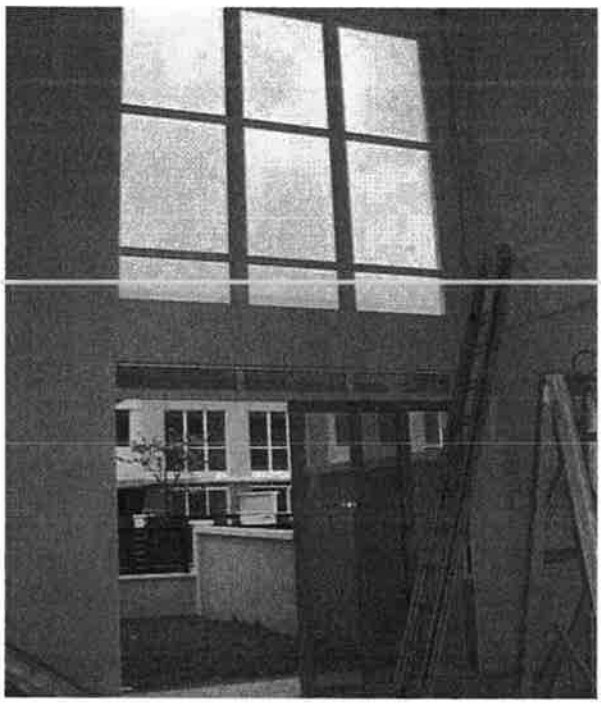
4.17 Single PVC insulated cable installed without conduit or trunking

Non-sheathed cables for fixed wiring shall be enclosed in conduit, ducting or trunking.

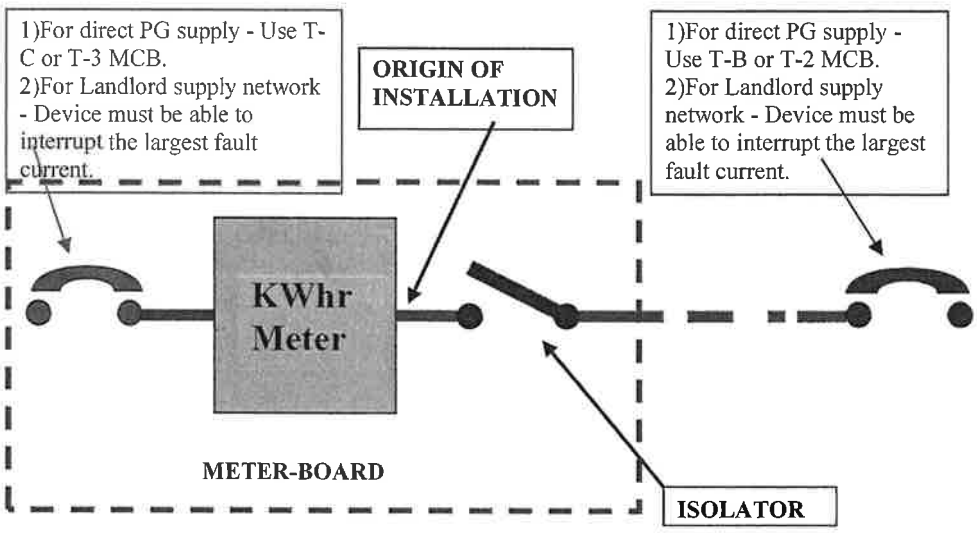


4.18 SSO for general purpose installed above 1.8m

SSO for general purpose shall be mounted at a height not more than 1.8m from the floor or working platform.

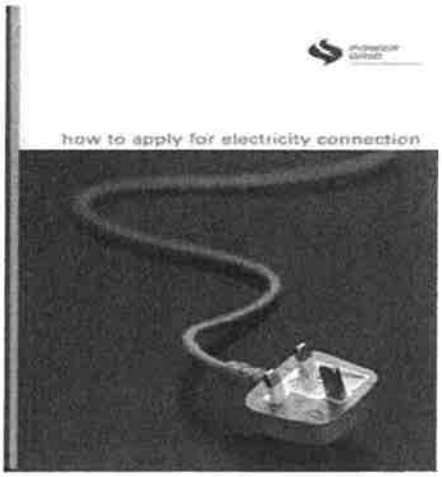


4.19 Wrong sequence of control at meter board



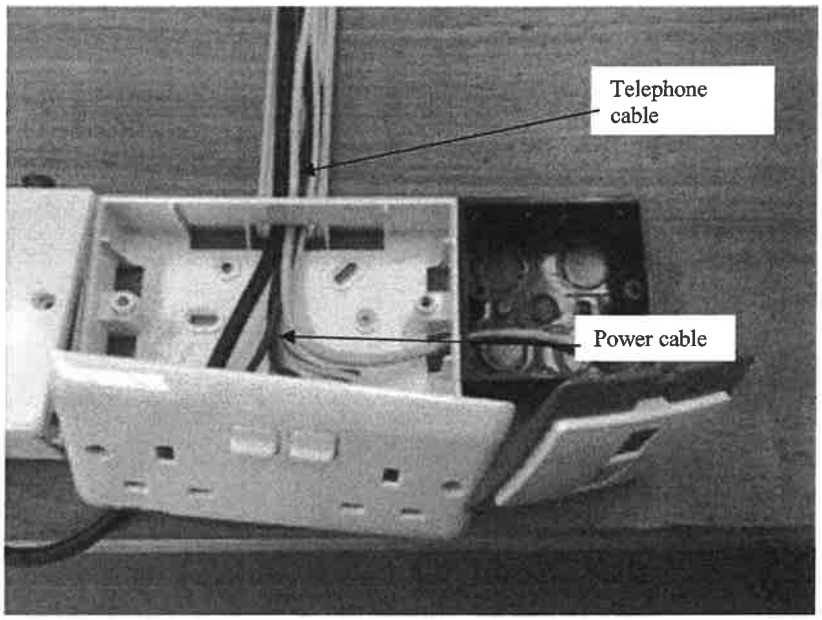
4.20 Meter board/meter compartment at gatepost not complying with requirements.(SP PowerGrid Requirement)

Detailed Information on meter board/meter compartment at gatepost could be obtained from SPPowerGrid's "Application for Electricity Supply" handbook which is available at SPPG website.



4.21 Cable in same conduit/trunking/duct with other services

Sharing of power cables with telephone and SCV cables in the same conduit.

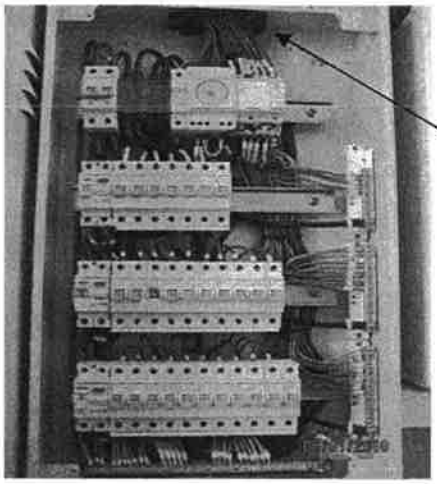


4.22 Wiring encroaching into other premises/electrical installation

Effective means, suitably placed for every operation, shall be provided so that all voltage may be cut off from every installation, from every circuit and from all equipment to prevent or remove danger.

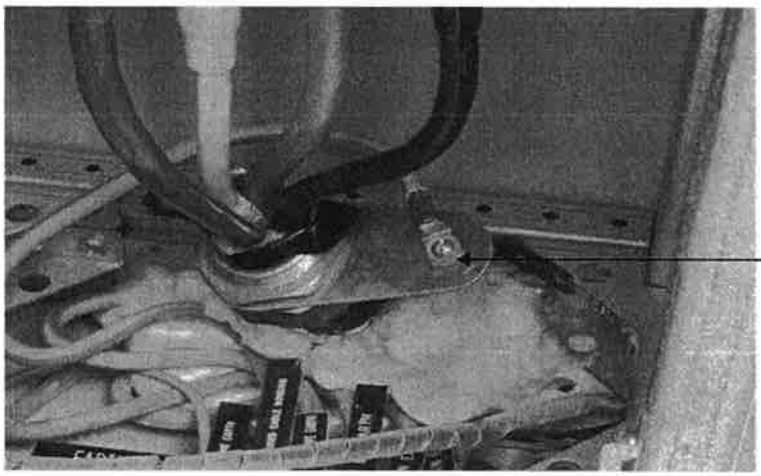
4.23 No provision of PVC or rubber grommet/bushing at metallic sharp edges to prevent damage of cable insulation

A wiring system shall be selected and erected so as to minimize during installation, use and maintenance, damage to the sheath and installation of cables and insulated conductors.



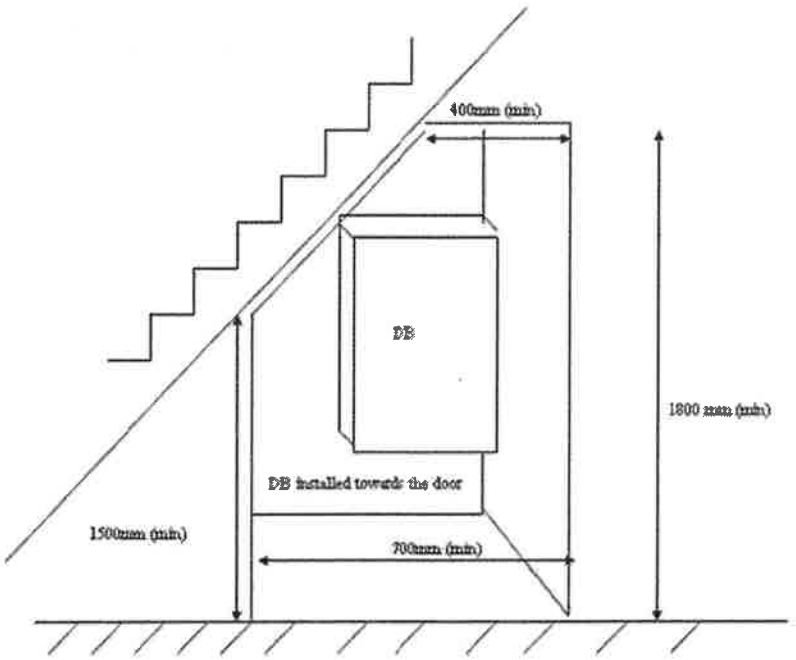
4.24 Cable armour improperly bonded or not bonded to earth

Both ends of the amour must be earthed.



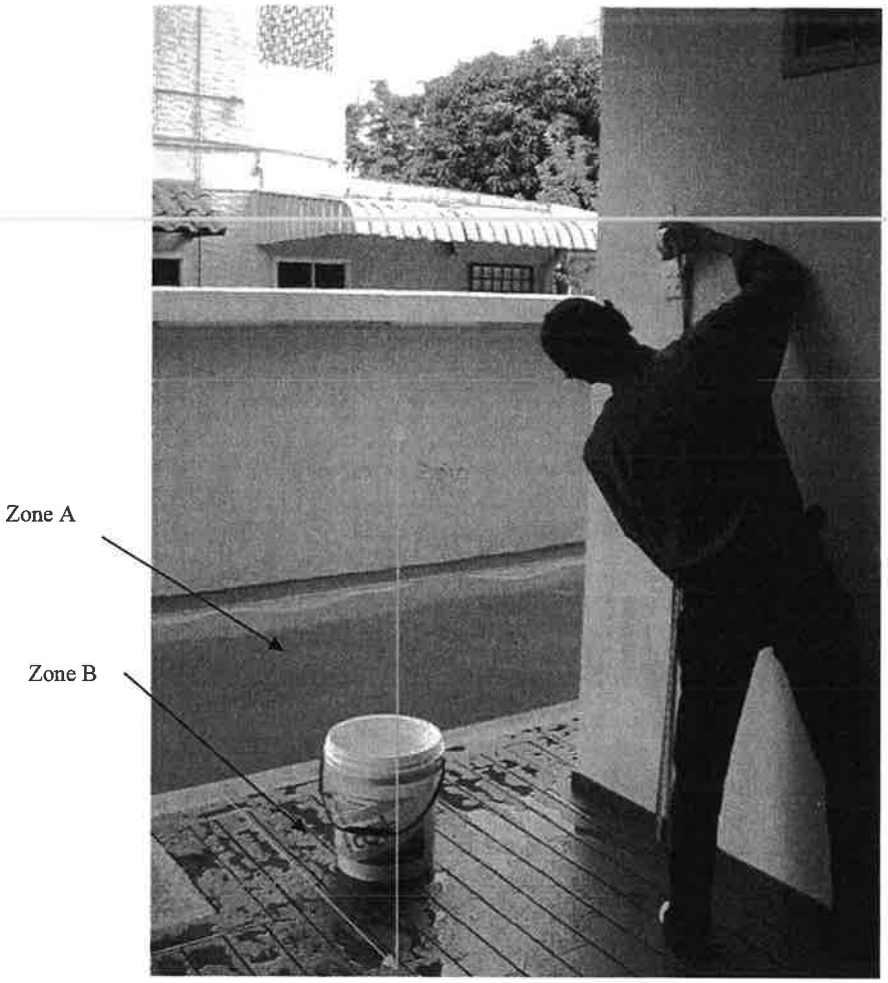
4.25 DB located under the staircase

There must have adequate clear space around every outer edge of the front, sides and back of the DB to enable the safe operation, inspection testing and maintenance. Also, a passage leading to the DB must be kept free from any obstruction.



4.26 Improper Installations

Accessories shall not be installed at zone A and zone B of the swimming pool area except supplied via SELV at a nominal voltage not exceeding 12V ac or 30V dc.



TOPIC 6: HIGHLIGHTS IN CODES OF PRACTICE (CP5 & CP88)

1 Introduction to CP5

This Singapore Standard was prepared by the Technical Committee on the Code of Practice for Electrical Installations under the direction of the Electrical Industry Practice Committee.

This code of practice has been drawn up to ensure safety, especially from electric shock and fire in the use of electricity and relates principally to the design, selection, erection, inspection and testing of electrical installations. It is not intended to take the place of detailed specification or to instruct untrained persons or to provide for every circumstance. For installations of a special or complex character, the advice of a suitably qualified professional engineer and consultation with the supply authority will be necessary.

1.1 Contents of CP5: 1998

The contents of CP5: 1998 includes: -

Part 1 - Scope, Object And Fundamental Requirements For Safety
Part 2 - Definitions
Part 3 - Assessment Of General Characteristics
Part 4 - Protection For Safety
Part 5 - Selection And Erection Of Equipment
Part 6 - Special Installations Or Locations
Part 7 - Inspection And Testing
Appendices

2 Fundamental Requirements For Safety

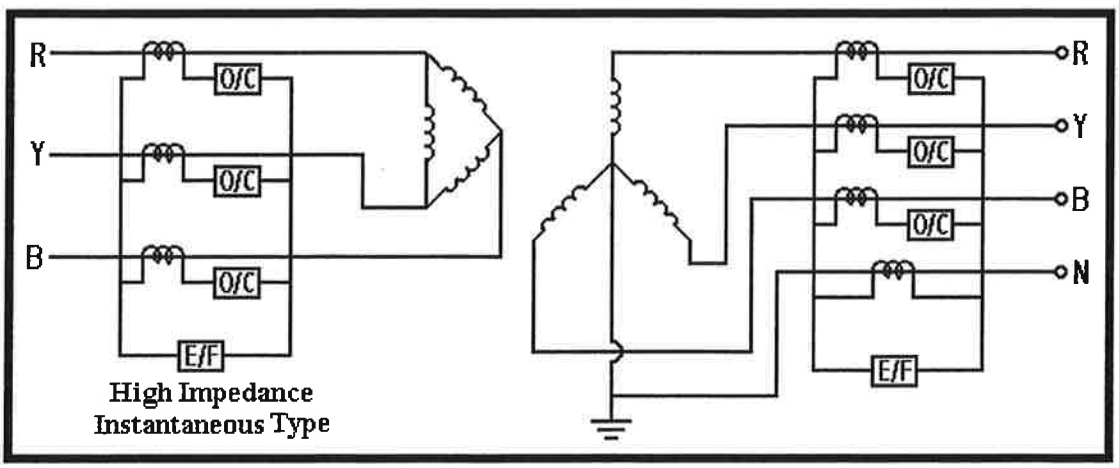


Figure 1

2.1 Overcurrent Protection

Singapore Standard CP5: 1998, Code of practice for electrical installations requires that:-

Clause 130-03-01 Where necessary to prevent danger, every installation and every circuit thereof shall be protected against overcurrent by devices which:

(i) will **operate automatically** at values of current which are suitably related to the safe current rating of the circuit, and

(ii) are of **adequate breaking** capacity and, where appropriate, making capacity, and

(iii) are **suitably located** and are constructed so as to prevent danger from overheating, arcing or the scattering of hot particles when they come into operation and to permit ready restoration of the supply without danger.

2.2 Earth Leakage Protection

Clause 130-04-01, 130-04-02, 130-04-03 and 130-04-04 of the Singapore Standard CP5: 1998 also require that:-

130-04 Precautions Against Earth Leakage and Earth Fault Currents

130-04-01 Where metalwork of electrical equipment, other than current-carrying conductors, may become charged with electricity in such a manner as to cause danger:

(i) the metalwork shall be connected with earth in such a manner as will cause discharge of electrical energy without danger, or

(ii) other equally effective precautions shall be taken to prevent danger.

130-04-02 Every circuit shall be arranged so as to prevent the persistence of dangerous earth leakage currents.

130-04-03 Where metalwork is connected with earth in accordance with Clause 130-04-01 (i) the circuits concerned shall be protected against the persistence of an earth fault current by:

(i) the overcurrent protective devices required by Clause 130-03-01, or

(ii) **a residual current device** or equally effective device.

The method described in item (ii) above shall be used whenever the prospective earth fault current is insufficient to cause prompt operation of the overcurrent protective devices.

130-04-04 Where metalwork of electrical equipment is connected with earth in accordance with Clause 130-04-01(i) and is accessible simultaneously with substantial exposed metal parts of other services, the latter shall be effectively connected to the main earthing terminal of the installation.

2.3 Isolation and Switching

Clauses 130-06-01, 537-02-01 & 537-02-02L of CP5: 1998 requires that:-

130-06 Isolation and Switching

130-06-01 Effective means, suitably placed for ready operation, shall be provided so that all voltage may be cut off from every installation, from every circuit thereof and from all equipment, as may be necessary to prevent or remove danger.

537-02 Devices For Isolation

537-02-01 Except as detailed by Clause 460-01-04, the devices for isolation shall effectively isolate all live supply conductors from the circuit concerned. Equipment used for isolation shall comply with Clauses 537-02-02 to 537-02-10.

537-02-02L The isolating distance between contacts or other means of isolating when in the open position shall be not less than that determined for an isolator (disconnector) in accordance with the requirement of IEC 947-3.

3 Assessment Of General Characteristics Of Electrical Installation

(a) Clause 300-01-01, in the design of electrical installation, an assessment shall be made of the following characteristics of the installation:

(i) the purpose of which the installation is intended to be used and its supplies
(ii) the external influences to which it is to be exposed
(iii) the compatibility of its equipment
(iv) its maintainability

These characteristics shall be taken into account in the choice of methods of protection for safety and the selection and erection of equipment.

(b) Clause 312-02-01, the number and type of live conductors shall be determined, whether it should be:

(i) single phase two-wire A.C.
(ii) three phase four-wire A.C.
or (iii) three phase 3-wire A.C.

(c) Clause 312-02-03, the type of earthing system to be used for the installation shall be determined, whether is should be:

(i) TT system
(ii) TN-S system

(d) Clause 312-01-01, the following characteristics of the supply or supplies, from whatever source, and where appropriate the normal range of those characteristics, shall be determined by calculation, measurement, enquiry or inspection:

(i) the nominal voltage(s)
(ii) the nature of the current and frequency
(iii) the prospective short-circuit current at the origin of the installation
(iv) the earth fault loop impedance of that part of the system external to the installation (Z_e).
(v) the suitability for the requirements of the installation, including the maximum demand.
(vi) the type and rating of the overcurrent protective device acting at the origin of the installation.

(e) Installation Circuit Arrangement

(i) Clause 314-01-01, every installation shall be divided into circuits as necessary to:

- avoid danger in the event of a fault, and
- facilitate safe operation, inspection, testing and maintenance.

(ii) Clause 314-01-02, a separate circuit shall be provided for each part of the installation which needs to be separately controlled for compliance with the Regulations or otherwise to prevent danger, so that such circuits remain energized in the event of failure of any other circuit of the installation, and due account shall be taken of the consequences of the operation of any single protective device.

(iii) Clause 314-01-03, the number of final circuits required, and the number of points supplied by any final circuit, shall be such as to facilitate compliance with the requirements of overcurrent protection, the requirement of isolation and switching and the requirement of current-carrying capacities of conductors.

(iv) Clause 314-01-04, where an installation comprises more than one final circuit, each final circuit shall be connected to a separate way in a distribution board. The wiring of each final circuit shall be electrically separate from that of every other final circuit, so as to prevent the indirect energizing of a final circuit intended to be isolated.

4 Protection Against Electric Shock Protection Against Direct And Indirect Contact

Clause 411-01-01 – protection by SELV and limitation of discharge of energy.

Extra low. 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.

4.1 Protection against Direct Contact

(1) Clauses 412-01 to 412-05 explain the four basic measures for protection.

(2) Clause 412-06 requires the use of RCDs as supplementary protection.

CP5: 1998

412-03 Protection By Barriers or Enclosures

412-03-01 Live parts shall be inside enclosures or behind barriers providing at least the degree of protection IP2X or IPXXB except that, where an opening larger than that permitted for IP2X or IPXXB is necessary to allow the replacement of parts or to avoid interference with the proper functioning of electrical equipment both of the following requirements apply;

(i) suitable precautions shall be taken to prevent persons or livestock from touching a live part unintentionally, and

(ii) it shall be established, as far as practicable, that a person will be aware that a live part can be touched through the opening and should not be touched. (See Clause 471-05-02).

412-03-02 The horizontal top surface of a barrier or enclosure, which is readily accessible, shall provide a degree of protection of at least IP4X.

IEC 60439

7.4.2.2.1 All external surfaces shall conform to a degree of protection against direct contact of at least IP2X or IPXXB. The distance between the mechanical means provided for protection and the live parts they protect shall not be less than the values specified for the clearances and creepage distances, unless the mechanical means are of insulating material.

7.4.2.2.2 All barriers and enclosures shall be firmly secured in place. Taking into account their nature, size and arrangement, they shall have sufficient stability and durability to resist the strains and stresses likely to occur in normal service without reducing the clearances.

4.2 Protection against Indirect Contact

Clause 413-01-01 For protection against indirect contact, one of the following basic measures shall be used in accordance with the relevant requirements of this section and the application rules specified in Section 471, including those indicated below:

(i) Protection by earthed equipotential bonding and automatic disconnection of supply.

(ii) Protection by Class II equipment or by equivalent insulation.

(iii) Protection by non-conducting location.

(iv) Protection by earth-free local equipotential bonding

(v) Protection by electrical separation

Clause 413-02-07L and Clause 413-02-19

One or more of the following types of protective device shall be used, former being preferred: -

(a) A residual current device
(b) An overcurrent protective device

For TN-S Earthing System

Clause 413-02-16

The following condition shall be fulfilled: -

$Z_s \times I_{\Delta n} < 50V$, where $I_{\Delta n}$ is the operating current of RCD.

For TT Earthing System

Clause 413-02-20

The following condition shall be fulfilled:

$R_a \times I_a \leq 50V$, where I_a is the operating current of RCD.

5 Protection Against Overcurrent

5.1 Overcurrent

An 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 or fault current.

These conditions need to be protected against in order to avoid damage to circuit conductors and equipment. In practice, fuses and circuit breakers are used to protect against overloading or short-circuit.

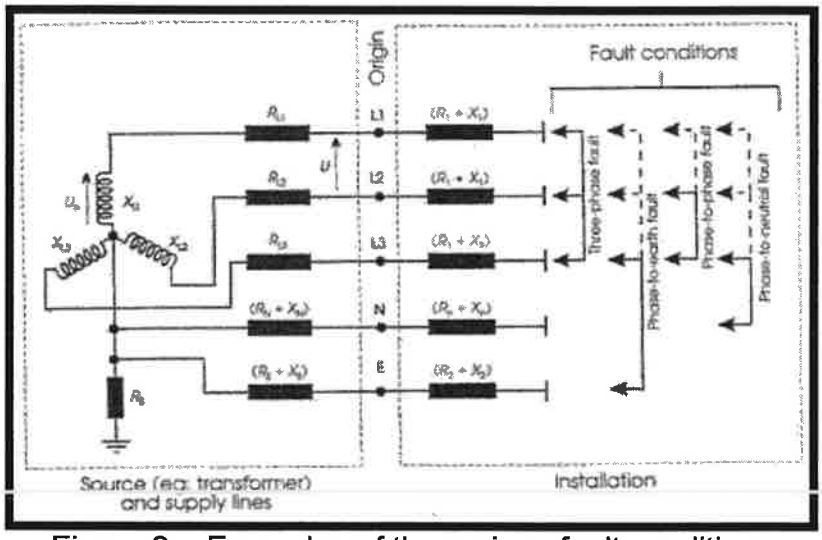


Figure 2 – Examples of the various fault conditions

5.2 Overcurrent Protection Devices

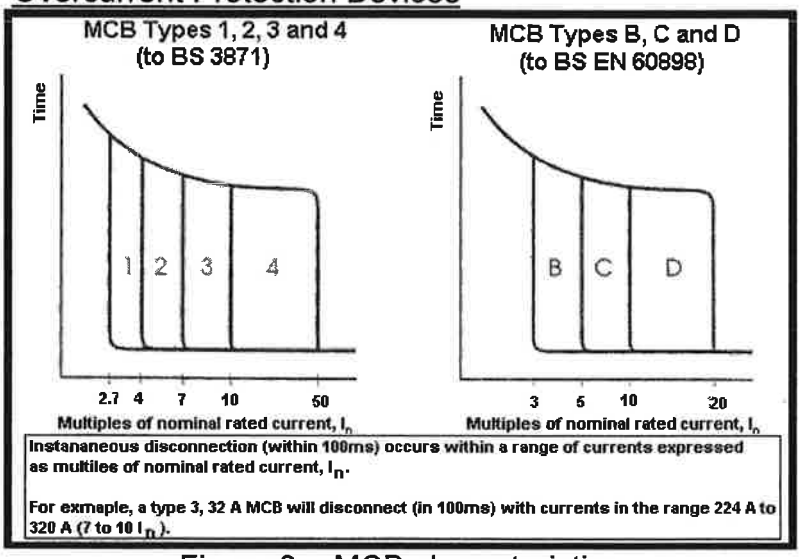


Figure 3 – MCB characteristics

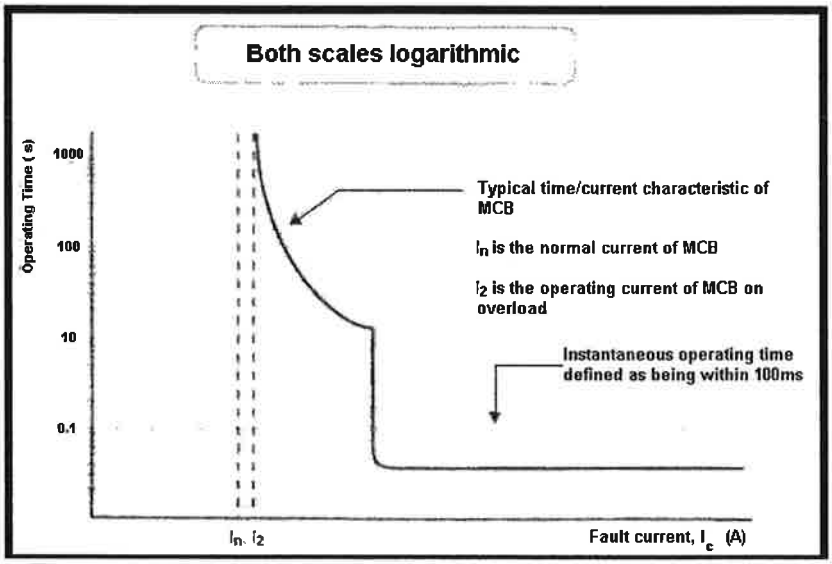


Figure 4 – Typical operating characteristics of an MCB

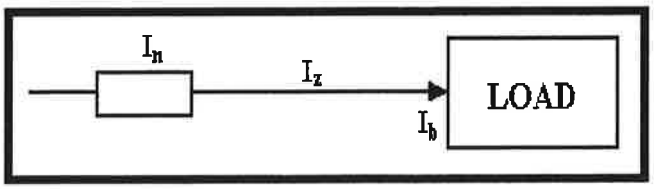
5.3 Overload Consideration

Protection of Cable against Overload Current and Consideration with Protection Device

For some types of cable, particularly wiring cables, the required current rating of the cable must be determined by the overload protective device rather than the circuit current. The rating of the device must not be less than the circuit designed current and, of course, such ratings are in discrete steps.

To provide an adequate protection against overloading, the code of practice for electrical installations requires that the following conditions to be satisfied.

(a) $I_b \leq I_n \leq I_Z$
(b) $I_2 \leq 1.45\ I_Z$



Where
I_b = Design Current of Circuit
I_n = Nominal Current of Protective Device
I_Z = Effective Current Carrying Capacity of Conductor

Figure 5

It means:

(a) The nominal current (I_n) of the protective device must be greater or equal to the design current (I_b) of the circuit so that the device will not trip under normal conditions.

(b) The current-carrying capacity of the conductor (I_Z) must be greater than or equal to I_n, so that the device will trip before damage to the cable.

(c) The current that will operate the protective device (I_2) must not exceed 1.45 times the lowest I_Z of the conductors.

Example:

A circuit with 4 x 16mm^2 PVC single core cable with designed load current, I_b = 52A is protected by a 60A (i.e. I_n = 60A) MCCB with minimum operating current 1.3 x I_n.

(a) Determine the current carrying capacity of the cable and whether the clause 433-02-01 of SS CP5: 1998 on protection against overloading is complied with, assuming ambient temperature is 30°C.

(b) Determine the minimum operating current of the MCCB as required by IEC 947-2 and whether the circuit is adequately protected against overloading.

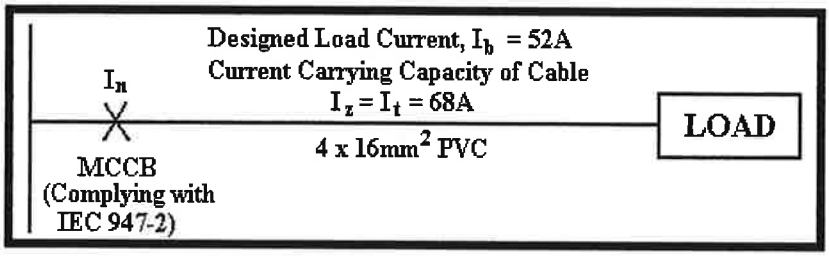


Figure 6

Solution:

(a) From Table 4D1A of SS CP5: 1998, the current carrying capacity of 16mm^2 PVC cable is 68A, i.e. I_Z = 68A at 30°C.

Since I_n = Protection device nominal current = Rating 60A
I_b = Designed continuous load current = 52A
$I_b \leq I_n \leq I_Z$, Clause 433-02-01 is complied with.

(b) Since minimum operating current of protection device,

I_2 = 1.3 x I_n
= 1.3 x 60 = 78A

and 1.45 I_Z = 1.45 x 68 = 98.6A

The requirement of $I_2 \leq 1.45\ I_Z$ is also satisfied, therefore this circuit is provided with adequate overload protection.

However, it is to be noted that though the cable can effectively carry 68A continuously and the MCCB will operate at 78A, there is a small range of current from 68A to 78A for which the cable may be slightly overloaded and become warm. Selection of a bigger size cable (next bigger size) will avoid this problem and also minimize the losses on the cable.

5.4 Short Circuit Consideration

Protection of Cable against Fault Current

Often the conductor size is determined by short-circuit current considerations rather than continuous current requirements. The short-circuit current, which may be 20 or more times the normal continuous current, produces thermal and electromagnetic effects proportional to the square of the current. So far as the cable insulation itself is concerned, much higher conductor temperatures

may be produced and the full temperature will not be sustained for significant time by the insulation.

Short-circuit ratings are not published for individual cables in any official documents, because of the large number of the cable types and sizes involved and the fact that they have to be related to the duration of short circuit which applies to the particular circuit.

IEE regulation and SS CP5: 1998 specifies in Clause 434-03-03 that under fault condition, the clearance time of the protection device shall not result in the admissible limiting temperature of any live conductor being exceeded:

The formula used is $k^2S^2 \geq I_{SC}^2t$

The *t*, in which a given fault current will raise the live conductors from the highest permissible temperature in normal duty to the limiting temperature, can, as an approximation, be calculated from the formula:

$$t = \frac{k^2S^2}{I_{SC}^2}$$

where:

t is the duration in seconds,

S is the nominal cross sectional area of conductor in mm^2,

I_{SC} is the value of fault current in amperes, expressed for A.C. as the r.m.s. value, due account being taken of the current limiting effect of the circuit impedances.

k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperature. For the common materials indicated in Table 43A, the k factor shall be as shown in table 43A of SS CP5: 1998.

Typical values of k are: k = 115 for PVC Copper Cable
k = 143 for XLPE Copper Cable

Clause 533-03-01 of CP5: 1998 requires that maximum fault current at the origin of the protective device and minimum fault current at the remote end of the conductor be calculated so that the adiabatic equation in Clause 434-03-03 be calculated in both conditions.

533-03 Selection Of A Device For Protection Of A Wiring System Against Fault Current

533-03-01 The application of the rules of Chapter 43 shall take into account minimum and maximum fault current conditions.

The calculation of Maximum & Minimum Fault Current shall be as follows:

- For a single phase circuit, I_{SC} (Max) is the phase to Neutral Short Circuit Current at the origin of the protective device and I_{SC} (Min) is the phase to Neutral Short Circuit Current at the remote end of the circuit.
- For 3-phase 4 wires system, the I_{SC} (Max) is the symmetrical short circuit current at the origin of the protective device and I_{SC} (Min) is the phase to Neutral Short Circuit Current at the remote end of the circuit.

- For a 3-phase 3 wires system, the I_{SC} (Min) is the symmetrical short circuit current at the origin of the protective device and I_{SC} (Min) is the phase to phase short circuit current at the remote end of the circuit.

6 TT Earthing System & TN-S Earthing System

In Singapore, two types of electrical earthing systems are permitted; these are the TT earthing system and TN-S earthing system.

6.1 TT Earthing System

(a) TT earthing system is used when consumers receive electricity supply at 400V/230V.

(b) As the distribution transformer is installed on the power supply company side, Neutral earthing electrode system is installed at the power supply company's substation.

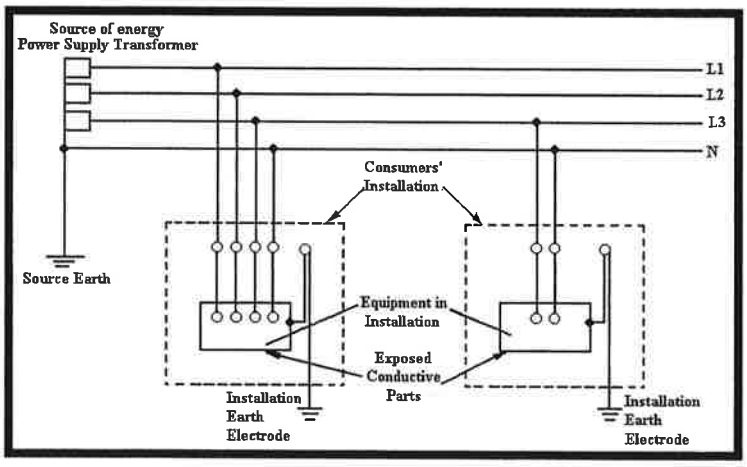


Figure 7 – TT Earthing System

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

Definition for the Designation 'TT'

The first letter denotes the earthing arrangement at the source of energy, and

T = Direct connection of one or more points to Earth

The second letter denotes the relationship of the exposed conductive parts of the installation to earth, and

T = Direct electrical connection of the exposed conductive parts to Earth, independently of the earthing of any point of the source of energy.

(c) Earth fault loop impedance of TT earthing system is given as

$$Z_{ELFI} = Z_T + Z_P + Z_E + (R_B + R_A) + Z_{N/E}$$
$$\approx (R_A + R_B)$$

where Z_T = Transformer winding impedance
Z_P = Phase conductor's impedance
Z_E = Earth conductor's impedance
$Z_{N/E}$ = Neutral to Earth conductor impedance
R_A = Installation earth electrode resistance
R_B = Neutral earth electrode resistance

6.2 TN-S Earthing System

(a) TN-S earthing system is used when the consumers receive electricity supply at high voltage (22kV or 6.6kV supply in Singapore).

(b) As the distribution transformers are installed on the consumer side, system neutral earthing and installation earthing (i.e. safety earthing for consumer's electrical equipment) share the same electrode system.

The protective conductor (PE) is the metallic covering of the cable supplying the installations or a separate earth conductor.

All exposed-conductive-parts of an installation are connected to this protective conductor via the main earthing terminal of the installation.

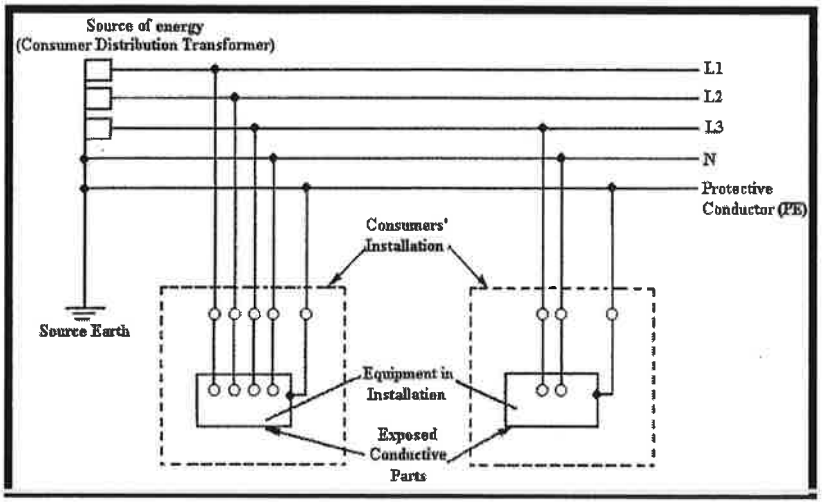


Figure 8 – TN-S System

Definition for the Designation 'TN- S'

The first letter denotes the earthing arrangement at the source of energy, and

T = Direct connection of one or more points to Earth

The second letter denotes the relationship of the exposed conductive parts of the installation to earth, and

N = Direct electrical connection of the exposed conductive parts to the Earth point of the source of energy, which, is usually the Neutral point.

The third letter 'S' denotes the separate conductors being used for Neutral and Earth.

S = Separate conductors for Neutral & Earth

(c) Earth Fault Loop Impedance of TN-S earthing system does not include any of the earth electrode system;

$$Z_{EFLI} = Z_T + Z_P + Z_E + Z_{N/E}$$

where Z_T = Transformer winding impedance

Therefore Phase to Earth Fault current,

$$I_{E/F} = \frac{V_{PH}}{Z_{EFLI}} = \left(\frac{V_{PH}}{Z_T + Z_P + Z_E + Z_{N/E}} \right)$$

Z_P = Phase conductor's impedance
Z_E = Earth conductor's impedance
$Z_{N/E}$ = Neutral to Earth conductor impedance

Note that earth electrode resistance R_B for neutral earthing is not included in the Z_{EFLI} formula.

6.3 Protection against electric shock by Indirect Contact

TN-S Earthing System

413-02-16 If protection is provided by a residual current device the following condition shall be fulfilled:

$$Z_s I_{\Delta n} \leq 50 \text{ V}$$

Where:

Z_s is the earth fault loop impedance in ohms.

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

TT Earthing System

413-02-20 The following condition shall be fulfilled for each circuit:

$$R_a I_a \leq 50 \text{ V}$$

Where:

R_a is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed-conductive-part.
I_a is the current causing the automatic operation of the protective device within 5 s;

When the protective device is a residual current device, i_a is the rated residual operating current $I_{\Delta n}$.

6.4 Installation Earthing

A typical earthing arrangement of an electrical installation is shown in Figure 9.

Note:

(a) Cross-sectional area of main equipotential bonding cable shall not be less than half of the cross-sectional area of the main earthing conductor of the installation.

(b) Cross-sectional area of earthing conductor for cable tray and cable trunking shall not be less than the biggest CPC or earth conductor within the cable tray and cable trunking.

Definitions:

(a) Exposed Conductive Part

Exposed Conductive Part is defined as a conductive part of electrical equipment which can be touched and which is not a 'Live' part but which may become live under fault conditions.

Exposed conductive parts of electrical installation essentially include:

(i) Metallic Enclosure of electrical equipment & electrical appliances

(ii) Metallic Enclosure of electrical Switchboard (MSB & SB) & Distribution Boards (DB)

(iii) Metallic cable tray & cable trunking
- connection of cable tray & cable trunking are considered as earthing for electrical safety and not bonding.

(b) Extraneous Conductive Part

Extraneous conductive part is defined as a conductive part of non-electrical services which does not form part of the electrical installation, but is likely to introduce an earth potential.

Extraneous Conductive Parts in the buildings include non electrical services such as:

(i) Water pipes & gas pipes
(ii) Air-conditioning ducting
(iii) Fire protection, wet risers and sprinkler pipings

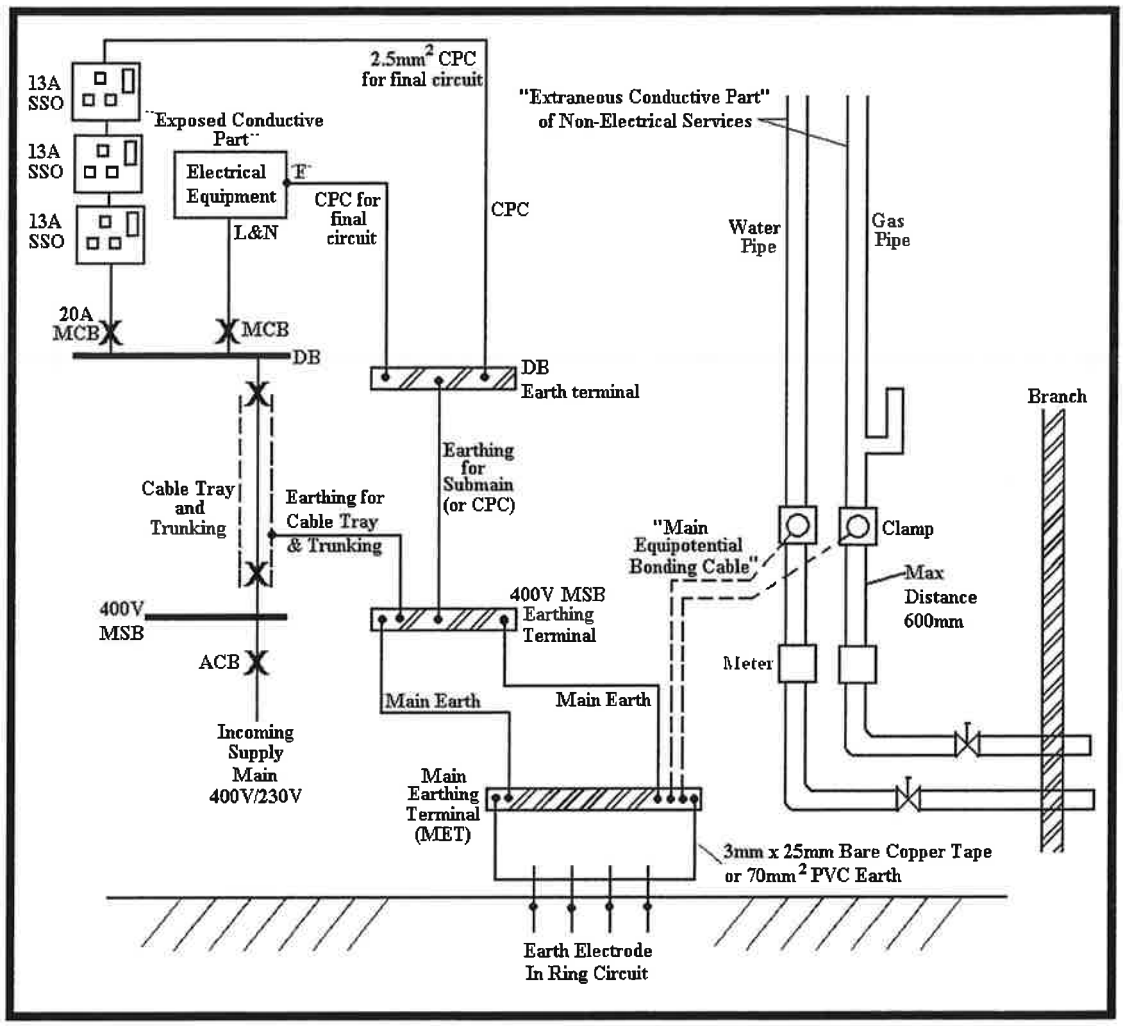


Figure 9 – Typical Earthing arrangement for TT System

As these extraneous conductive parts form a separate earthing system in the building and introduce an earth potential, it is possible that a person could simultaneously touch the exposed conductive part (e.g. metal enclosure of electrical equipment) and the extraneous conductive part (e.g. the water pipe and gas pipe), which may introduce a potential difference especially when the electrical equipment develops a fault and becomes 'live' or partially 'live'

(c) Main Equipotential Bonding Conductor

To eliminate or minimise the potential difference that may exist between exposed conductive part and extraneous conductive part. A bonding conductor is used to connect the extraneous conductive part such as a water pipe & gas pipe to the Main Earthing Terminals (MET) of the electrical system to create an equipotential zone. This is known as main equipotential bonding as shown in Figure 10.

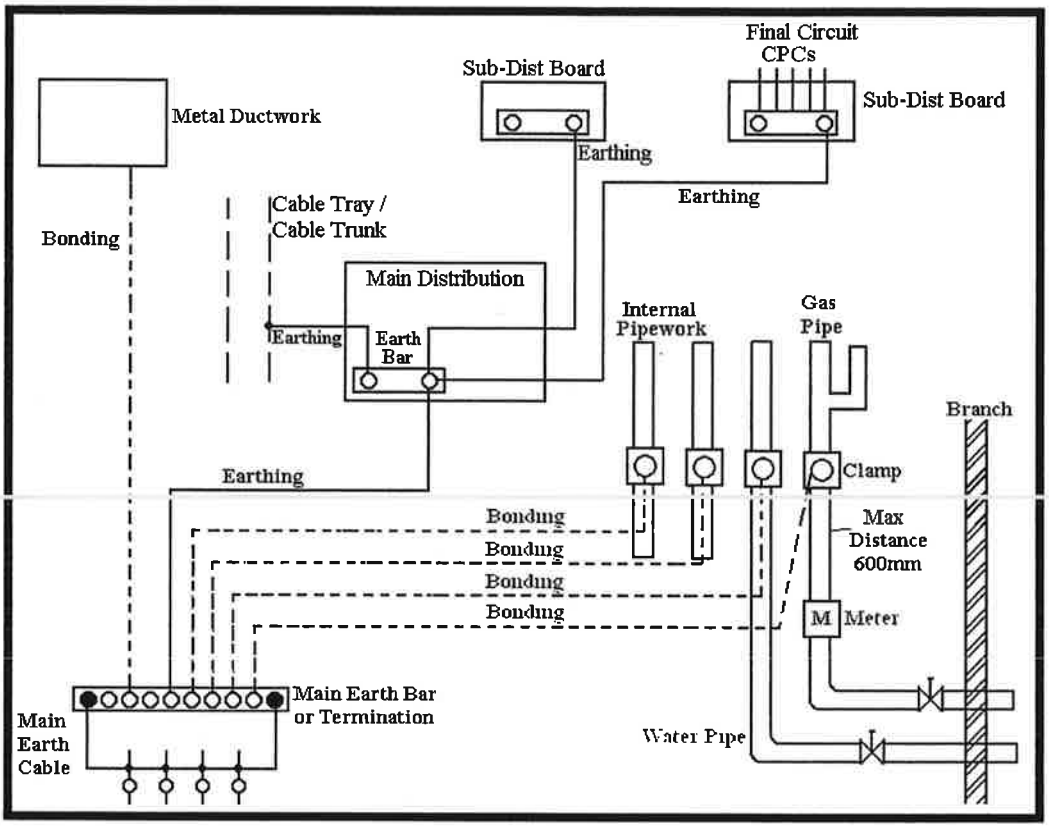


Figure 10 – Earthing & Main Equipotential Bonding

Note:
Clause 547-02-01L of SS CP5: 1998
The main equipotential bonding conductor shall have a cross sectional area not less than half the cross sectional area required for the earthing conductor of the installation.

(d) Circuit Protective Conductors (CPC)

Circuit protective conductor (CPC) is defined as a protective conductor connecting exposed-conductive-parts of electrical equipment to the main earthing terminal.

Size of earth cable on circuit protective conductors (S mm^2) may be determined by the formula given in Clause 543-01-03 of SS CP5: 1998

$$K^2S^2 \geq I_{E/F}{}^2 t \quad \text{or} \quad S = (\overline{I}_{E/F} \sqrt{t}) / K$$

where:

S is the nominal cross-sectional area of the conductor in mm^2.
$I_{E/F}$ is the value in amperes (r.m.s. for A.C.) of fault current for a fault of negligible impedance, which can flow through the associated protective device, due account being taken of

the current limiting effect of the circuit impedances and the limiting capability (I^2t) of that protective device.
Account shall be taken of the effect, on the resistance of circuit conductors, of their temperature rise as a result of overcurrent – see Clause 413-02-05 of SS CP5: 1998.
t is the operating time of the disconnecting device in seconds corresponding to the fault current / amperes.
k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures.

Values of k for protective conductors in various use or service are as given in Tables 54B, 54C, 54D, 54E and 54F. The values are based on the initial and final temperatures indicated below each table.

For example: k = 143 for PVC insulated copper Earth cable or CPC not bunched with the phase conductors and k = 159 for bare copper earth cable or CPC where there is no risk of damage to neighbouring material.

Where the application of the formula produces a non-standard size, a conductor having the nearest larger standard cross-sectional area shall be used.

6.5 CPC for Final Circuits and Submains

However, due to the non-availability of t, the operating time of disconnection device, rule of thumbs as given by table 54G of SS CP5: 1998 is often used by designers as a guide to sizing of CPC for submains and final circuits. The size of CPC is determined based on the size of phase conductor in accordance with Table 54G.

From table 54G of CP5: 1998: -

Size of CPC in Relation to the Size of Phase Conductor

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

Table 1 – Minimum cross-sectional area of CPC in relation to cross-sectional area of phase conductors

6.6 Main Earth Cable

Cross-sectional area (S mm^2) for main earth cable should be determined carefully by the following considerations:

(i) Whether it is TT or TN-S earthing system

(ii) Magnitude of prospective phase to earth fault current $I_{E/F}$

(iii) Duration of the flow of prospective phase to earth fault current t seconds

If actual disconnection time of protective device is not known, maximum duration of 3 seconds or 1 second may be used.

(iv) Thermal stress on earth cable

The main earth cable or protective conductor must be able to conduct the full prospective phase to earth fault current (magnitude and direction) without excessively raising the temperature of the earth cable or protective conductor and causing expulsion of sparks or arcs that could initiate a fire or explosion.

(v) Low impedance path

The impedance of the protective conductor must be low enough to accept the full phase to earth current without causing a voltage drop enough to be dangerous.

Criteria: Touch Voltage < 50 Volts (Limit)

(vi) Earth Fault Loop Impedance: Operation of protective device

The total impedance of the earth fault loop circuit (Earth fault loop impedance) must permit sufficient earth fault current magnitude to operate the protective device in required disconnection time stipulated by SS CP5: 1998.

Example:

For distribution circuit or submain, CP5: 1998 impose **5 seconds** limit & for portable equipment connected to socket outlet CP5: 1998 impose **0.4 seconds** limit. (Refer to relevant clauses of CP5: 1998).

These limits can be achieved by the use of appropriate Residual Current Device (RCD).

6.7 Supplementary Bonding Conductor

Supplementary bonding may be required at locations of increased electric shock risk.

The supplementary bonding conductor shall have cross-sectional area

- Not less than smallest protective conductor connected to the exposed conductive parts
- Minimum of 2.5 sqmm with mechanical protection
- Minimum of 4 sqmm without mechanical protection

7 Amendment No. 1 to SS CP5: 1998

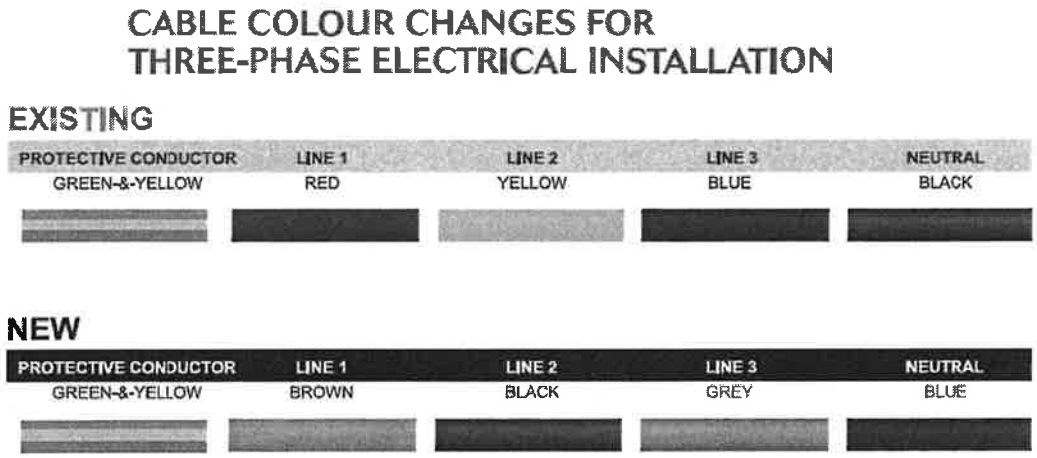
The amendment was launched on 27 Feb 2009

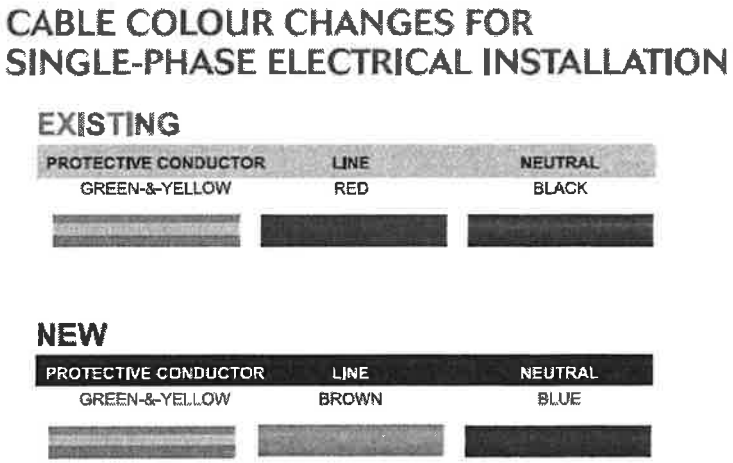
The amendment includes

(i) Change in cable colour code for fixed electrical wirings
(ii) Solar photovoltaic (PV) power supply systems

7.1 The Change In Cable Colour Code

The existing cable colour code for fixed electrical wiring stipulated in the SS CP5:1998 Code of practice for electrical installations has been amended to align with international standards such as BS 7671 and IEC 60446.

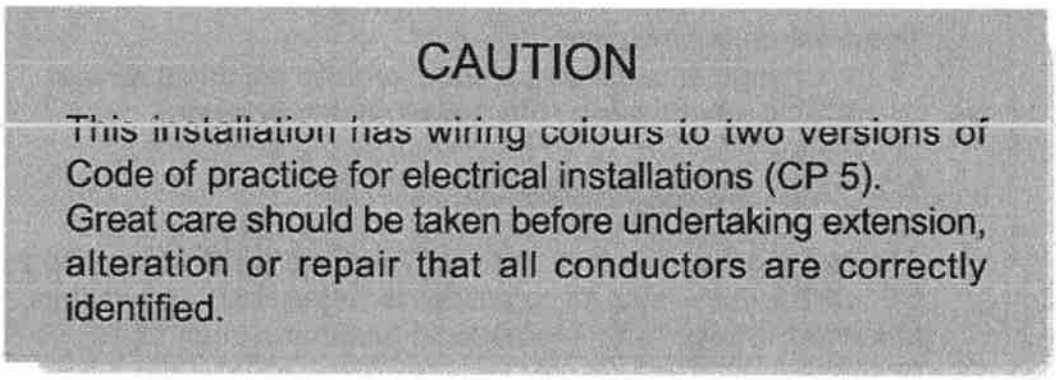




Only brown coloured cable can be used to identify line conductor of single-phase circuit.

7.2 Caution Notice

A caution notice shall be affixed conspicuously at the appropriate distribution board that controls the circuit where the new and old cable colour code exists.



NOTE: Warning Notice shall have words in black against a yellow background and shall be durably marked in legible type not smaller than that illustrated here.

7.3 Transition Period for Change

A transition period of 24 months from 1 Mar 2009 to 28 Feb 2011 is given before the new cable colour becomes mandatory on 1 Mar 2011.

During the transition period, either the old or new cable colour code, but not both, may be used.

Starting from 1 Mar 2011, the new cable colour code shall be used in all new electrical installations, as well as addition and alteration to existing electrical installations.

7.4 Solar Photovoltaic (PV) Power Supply System

A new section on PV power supply system has been included to SS CP5 with the Amendment No.1.

It provides requirements for PV power supply system connected to grid supply. Contents includes:

(i) Type of earthing arrangement
(ii) Protection for safety
(iii) Selection and erection of electrical equipment

8 Introduction To SS CP88 : Part 1 : 2001

8.1 Introduction

This Part of the Singapore Standard CP 88 was prepared by the Technical Committee on Temporary Electrical Installations under the direction of the Electrical Industry Practice Committee.

It was developed as a result of a review of the Singapore Standard CP 44 : 1998 – 'Code of practice for temporary electrical installations for construction and building sites'.

This Part of CP 88 is drawn up to supplement the general requirements of Singapore Standard CP 5 – 'Code of practice for electrical installations'. As installations operating at voltages up to 1000 V A.C. are widely used in construction and building sites, it is considered necessary to give guidance on good practice for the inspection, testing and maintenance of such installations. In addition, guidance on the installation of generating set and socket-outlet assembly are included to address the common use of generating set and socket-outlets for portable tools at these sites.

It is to be noted that for installations where separated extra low voltage (SELV) is used, references shall be made to the general requirements for protection by SELV in Singapore Standard CP 5.

Installations operating at voltages exceeding low voltage are outside the scope of this Part of the Code.

8.2 The Scope

This Part of the Code of Practice deals principally with temporary electrical installations for building operation and work of engineering construction. It applies to electrical installations set up for the provision of electricity supply during the execution of the following works:

(a) New building construction;
(b) Repair, alteration, extension or demolition of buildings;
(c) Engineering construction;
(d) Earthworks;
(e) Other similar works.

The requirements in this Code shall not apply to installations in construction site offices, meeting rooms, canteens, dormitories, toilets, etc., where the general requirements in the Singapore Standard CP 5 shall apply.

Although some temporary installations at these sites may receive supplies at voltages higher than 1000 V, such parts of the installations are outside the scope of this Code.

This Code also does not cover those aspects of installations in compressed air environment and potentially explosive atmospheres.

8.3 The Objective

The object of this Part of the Code is to protect persons and property against electrical hazards in the use of electricity in construction sites in view of the arduous duty imposed on the electrical equipment and wiring by the construction site conditions.

The general requirements of Singapore Standard CP5 shall be read in conjunction with this Part of the Code.

Because of variations in local circumstances of construction sites, the requirements of this Code are given in general terms, and will normally need to be supplemented by the advice of skilled persons.

9 The Salient Points Of CP88: Part 1

9.1 Source of Supply

Electrical installation at site may draw its supplies from the public electricity supply network or generating sets. Equipment shall be identified with and be compatible with the particular supply from which it is energized and shall contain only components connected to one and the same installation, except for control of signalling circuits and inputs from standby supplies. Due consideration shall be given to the fault level (prospective short-circuit current) at the point of supply.

9.2 Types of supply

(a) Mains voltages of public supply system

(i) Three-phase. 400V is the standard three-phase mains supply system voltage at 50Hz.

(ii) Single-phase. 230V is the standard single-phase mains supply system voltage at 50Hz.

(b) Supply voltage from generating sets

For a generating set supplying low voltages, unless otherwise approved by the skilled person responsible for the design and installation of supply installation, the output voltages shall be as follows:

(i) Three-phase. 400V between phases, and 230V between phases and Earth, 50Hz.

(ii) Single-phase. 230V between phase and Earth, 50Hz.

(c) 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.

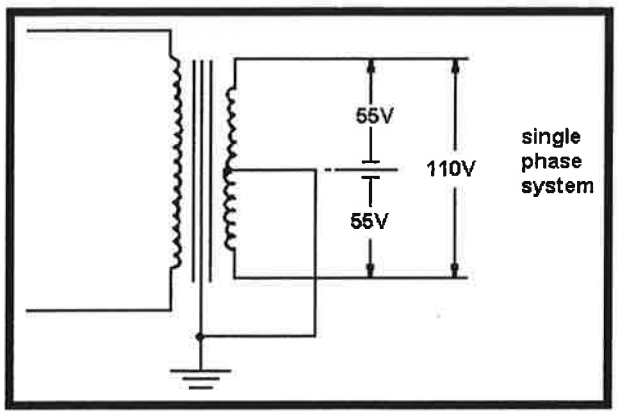


Figure 11 – Arrangement of transformer for safety 110V supply

(d) 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.

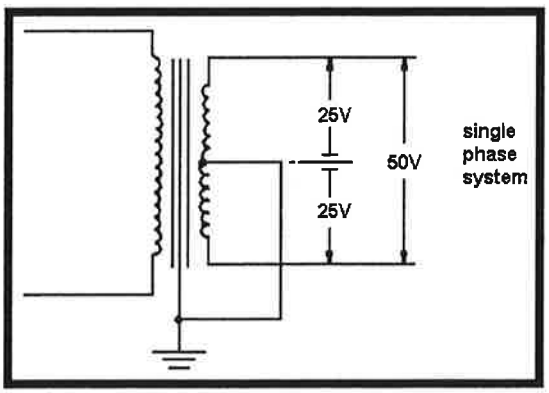


Figure 12 – Arrangement of transformer for safety 50V supply.

9.3 <u>No parallel operation of generating set and the public electricity supply system</u>

No parallel operation of the generating set and the public supply system shall be allowed unless otherwise approved by the public electricity supplier. In a service area where electricity supply is taken from a generating set, no electricity supply from the public supply system shall be introduced into the same service area.

9.4 Supply for equipment

The following voltages shall not be exceeded:

1.	Fixed plant, moveable plant fed via a trailing cable, installations in site buildings such as site offices, workshops, canteens and quarters, fixed flood lighting and site lighting.	400V 230V	Three-phase, or single-phase
2.	Portable electric hand-held tools and portable hand-lamps.	230V	Single-phase
3.	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
4.	Portable electric hand-held tools and portable hand-lamps used in confined locations such as the insides of boilers, tanks, pipes, or in other similar situations.	50V	Single-phase, centre point earthed

9.5 Type of earthing arrangement

1. The earthing system for electrical installations drawing supply from generating sets shall be TN-S.

2. If more than one generating set are used within a site, the electrical installations shall either:

   (i) Share a common earthing system, or

   (ii) Have separate earthing systems and the electrical installations connected to different earthing systems are segregated effectively from one another or effectively bonded to prevent dangerous potential rise between conducting parts which a person can come into simultaneous contact.

   This requirement also applies to more than one electrical installations taking supply from the public supply system within the same site.

(iii) The design, selection and installation of protective conductors shall be in accordance with Singapore Standard CP5.

9.6 Installation of generating set

(a) General

Generating set shall be suitably barricaded to prevent access by non-authorised persons. Adequate clearance around generating set shall be provided to facilitate operation and maintenance work. Access leading to the generating sets shall be unimpeded to the skilled person or his representatives at all times. Any switch or control for stopping and starting the engines shall be readily accessible. In addition, generating set shall not be installed:

(i) In damp situations or exposed to the weather unless suitably protected; or

(ii) In hazardous areas, unless the equipment and method installation complies with BS 5345 and the additional requirements of any relevant authority.

Care shall be taken to have the fuel and its containers stored in a safe manner.

(b) Earthing arrangements of generating set

Electrical installation supplied from generating sets shall share a common TN-S earthing system with the generator or generators connected to it. In any electrical installation, a main earthing terminal or bar of adequate rating shall be provided and connected to the earthing conductors. 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 through adequately rated conductors to the earthing system of the installation.

In addition, the following parts of the generating sets shall be bonded together to form the generator bonding system which shall be connected effectively to the main earthing terminal:

(i) The engine frame;
(ii) The generator frame;
(iii) All exposed metal enclosure for electrical equipment and wiring;
(iv) Earth terminals of all socket-outlet (if any); and
(v) The main frame terminal (marked ⏚)

(c) Protection against direct contact of all live parts

All live parts of a generating set shall be protected against direct contact in accordance with Singapore Standard CP 5.

(d) Labelling on generating set

The following information shall be indelibly and legibly marked on a generating set:

(i) The name of the manufacturer of the set;
(ii) The model number and serial number of the set;
(iii) The type of fuel or fuel-oil mixture;
(iv) Rated output in watts or kilowatts at a stated power factor;
(v) The voltage and frequency;
(vi) Output terminal markings (unless all outputs are socket-outlets);
(vii) The frame terminal: symbol marked ⏚;
(viii) On a set intended for undercover or weather-protected usage, the words "NOT WEATHER-PROOF"
(ix) On a set intended for outdoor use without further protection, the IP classification of its electrical equipment.
(x) In addition, a danger sign board made of durable material with the word DANGER with the specification as detailed in Annex D shall be displayed at a prominent location near the generating set.

9.7 Protection for safety

(a) Control of supply

(i) General

Every electrical installation on construction sites shall be adequately controlled by switchgear readily accessible to the skilled person or his authorized representative in charge of the installation and shall incorporate:

- Means of isolation;
- Means of overcurrent and earth fault protection; and
- Means of earth leakage protection (except extra-low voltage installations)

(ii) Protective device for incoming supply

For an incoming supply up to 300A three-phase, a circuit breaker with residual current device shall be provided at the main switchboard.

For an incoming supply exceeding 300A three-phase, a circuit breaker incorporating overcurrent and earth fault protective devices shall be provided.

(iii) Protection of circuits

Appropriate electrical protection shall be provided for all circuits, including final circuits, against overload, short-circuit and earth-fault current. The protective devices shall be capable of interrupting without damage any fault current that may occur and due consideration shall be given to the fault level of the supply.

(iv) Prohibited use of fuses for final circuits

Fuses shall not be used for protecting final circuits in any part of the installation, except for those socket-outlets incorporated with fuse protection.

(b) Protection against direct contact

One or more of the following basic protective measure shall be used in accordance with the requirements in Singapore Standard CP 5:

(i) Protection by insulation of live parts,
(ii) Protection by a barrier or an enclosure,
(iii) Protection by obstacles,
(iv) Protection by placing out of reach.

(c) Protection against indirect contact for low voltage system

(i) Protection by residual current device

Protection against indirect contact shall be afforded using residual current devices and the following condition shall be fulfilled as appropriate to the type of earthing system:

For TN-S system: $Z_s I_{\Delta n} \leq 25$ V

Where:

Z_s is the earth fault loop impedance in ohms

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

For TT system: $R_a I_{\Delta n} \leq 25$ V

Where:

R_a is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed-conductive-part.

(ii) Protection by residual current device for final circuits

Except for final circuits supplying equipment which are protected by other appropriate measures as permitted under this Code and only accessible to and are operated by a skilled person, all other final circuits are to be protected by one or more residual current devices. The type and tripping sensitivities of residual current device to be used for the final circuit of the following rating shall be:

- Residual current circuit breaker with a tripping current not exceeding 30 mA and a tripping time within 0.1 s complying with SS 97 for final circuits of rating not exceeding 63 A three-phase or single-phase at mains voltage.

- Residual current circuit breaker with a tripping current not exceeding 300 mA complying with SS 97 for final circuits of rating exceeding 63 A but not more than 100 A three-phase or single-phase at mains voltage.

- Residual current device with a tripping current not exceeding 500 mA shall be used for final circuits of rating exceeding 100 A three-phase at mains voltage.

(iii) Earth leakage protection for transportable electrical equipment

For guidance on earth leakage protection for transportable electrical equipment, refer to Singapore Standard CP 16.

9.8 Selection and erection of equipment

(a) Wiring systems

(i) Every item of equipment shall be selected and erected so as to comply with the general requirements stipulated in the Singapore Standard CP 5 and the following clauses in this Section.

(ii) All cables to be laid direct in the ground shall be armoured cables.

(iii) Except for cables installed overhead, all other cables for submains or final circuits operating at voltages exceeding 63 V to Earth (Three-phase system) or 55 V to Earth (Single-phase system) and routed outdoor shall be of armoured construction and buried where possible.

(iv) All cables which are likely to be moved in normal use shall be flexible cables. Where trailing cables are required by nature of the work, they shall be of the armoured type complying with BS 6708 having an over-sheath of heavy duty oil-resisting and flame-retardant compound.

(v) 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.

(vi) Except for situations (e.g. switch rooms or control rooms) where the risk of mechanical damage is slight, armoured cables having an over-sheath of PVC or an oil-resisting and flame-retardant compound or cables with adequate mechanical protection shall be used.

(b) Flexible cords

(i) Flexible cords shall be of the circular type having heat resisting, oil resisting and flame-retardant rubber-sheath complying with IEC 60245 Part 1 or PVC insulated and PVC sheathed complying with SS 358: Part 5.

(ii) Flexible cords for portable hand-lamps shall be of the circular type having screened Type EM2 rubber-sheath complying with BS 6500.

(iii) Flexible cords of portable electrical equipment shall not exceed 3 m in length or such length as supplied by the original equipment manufacturer.

(iv) Flexible cords of conductor size smaller than 1.0 mm2 (32/0.20 mm) shall not be used.

(c) Installation of cables

(i) Cables, other than those supplying power to portable electrical equipment or mobile plant, shall be fixed on site so that they are clear of building operation or engineering construction work and are not a hazard to persons working on the site.

(ii) All cables are to be installed without obstruction to the use of passageways, walkways, ladders, stairs and the like.

(iii) Where submains cables inside a building or under a covered area are to be suspended or supported from the ceiling or wall, cable trays, brackets or other suitable supports shall be provided. The cable supports shall not cause damage to the cable insulation or subject the cables to undue mechanical stress.

(iv) Laying of cables on the ground or the floor of a structure shall be avoided. Where it is unavoidable to lay cables on the ground or the floor of a structure, the cables shall be of the armoured type complying with BS 6708 having an over-sheath of heavy duty oil-resisting and flame-retardant compound or PVC insulated, steel wire armoured and PVC sheathed complying with SS 443 and shall be laid in such a manner that the risk of mechanical damage is prevented.

(v) Elevated flexible cables used indoor shall be provided with suitable mechanical protection and securely supported in such a manner as not to damage the sheath of the flexible cables and not subject the cables or their terminations to undue mechanical stress.

(vi) No flexible cord shall be used as submain or final circuit for the purpose of distribution of electricity supply.

(vii) Cables buried direct in the ground shall be marked by cable covers and shall be buried at a minimum depth of 300 mm to avoid being damaged by any disturbance on the ground. The cable route for all supply cables and submains buried underground shall be marked on site drawings.

(viii) Cables passing under roadways or accessways for transport and mobile plant shall be laid at a minimum depth of 600 mm. A cable marker shall be installed at both ends of each crossing.

(ix) Overhead cables shall be so placed and at such height as to be out of reach of any source of mechanical damage reasonably to be foreseen in the area where they are erected.

(x) Overhead cables shall be installed at a height such that a clear vertical distance between the lowest part of the overhead cables and the highest point of vehicles, mobile cranes or other mobile plant likely to pass underneath them is 2 m minimum but under no circumstances shall the clear height to ground of the overhead cables be less than 5 m where they cross roadways or accessways.

(xi) Overhead cables shall be supported by catenary wires or proper cable support in a manner such that the cables are not subjected to undue mechanical stress. The catenary wires or metallic cable support shall be effectively bonded to Earth.

(xii) Poles supporting overhead cables shall be so located or arranged that the risk of mechanical or vehicular damage is prevented. Poles shall be sufficiently sized with adequate mechanical strength and properly anchored.

(xiii) Metal pole of minimum diameter 100 mm with adequate mechanical strength shall be used. Poles are made of wood or plastic material shall not be used for this purpose.

(xiv) All cables shall be installed so that they are at least 150 mm clear of piped services such as steam, gas and water and shall not be located directly below and parallel to these pipes.

(xv) All armoured cable terminations shall be provided with cable glands and earth tags for bonding to associated

gland plate and adjacent cables in order to maintain satisfactory earth loop impedance. The armour of the cable shall not however be relied on as circuit protective conductor for the cable.

(xvi) All joints shall be mechanically and electrically sound and fully insulated.

9.9 Switchgear and controlgear

Enclosure for low-voltage assembly

(a) The enclosure of each assembly for the distribution of electricity shall be robustly constructed so as to have adequate strength and rigidity to resist damage that could result from transportation, rough handling and heavy objects falling on it.

(b) Except for socket–outlet assembly, the enclosure for outdoor installation shall have:

(i) A degree of protection of at least IP44 to ensure the safe and satisfactory operation of the enclosed equipment; and

(ii) A roof so designed to prevent stagnation of water on its surface.

NOTE – It is recommended that the roof shall extend at least 76 mm beyond the main body of the enclosure.

(c) The enclosure shall be so placed, installed and safeguarded:

(i) To prevent damage by external influence that may affect the design and safe operation of the equipment; and

(ii) Shall be provided with adequate and safe means of access and working space for operation and maintenance purposes.

Switchboard and distribution board

Every switchboard and distribution board shall incorporate means for isolating and switching the incoming supply. Isolating switches or circuit breakers used for this purpose shall be suitable for securing in the OFF position.

9.10 Assembly of socket-outlet

Purpose of the SOA

The intention for the use of the SOA is to move the construction industry towards a more systematic approach in these setting up of temporary electrical installations.

Socket–outlet assembly (SOA)

One of the key recommendations in the CP 88 is the introduction of the use of socket-outlet assembly (or SOA). The SOA is basically a metal or plastic cabinet or box in which the various circuit protective devices are housed, and is typically equipped with up to six industrial socket-outlets.

These industrial socket-outlets will allow for the connection of portable electrical equipment such as electrical hand tools, lamps and welding sets and water-pumps.

Thus, it is necessary for each and every piece of portable electrical equipment to be connected up using only industrial plug. This will enable the equipment to be plugged directly into the industrial socket outlet fitted on the SOA.

The SOA has to be manufactured in accordance with standards specified in the CP. It can be designed for wall mounting or fitted with castors so that it can be moved around in the worksite.

Socket-outlets assembly

Socket-outlet assembly shall be used for the connection of portable electrical equipment at locations where fixed socket-outlets may not be available.

Enclosure for socket-outlet assembly

(a) The enclosure for the socket-outlet assembly shall be fabricated from:-

(i) Galvanised sheet steel of minimum 1.5mm thickness finished in epoxy powder coating; or

(ii) Aluminum sheet of minimum 2mm thickness finished in epoxy powder coating; or

(iii) Self-extinguishing, non-hygroscopic polycarbonate thermoplastic with high impact strength (6 joule), high resistance to UV rays, high resistance to chemical

elements and high resistance to abnormal heat and fire C (glow wire test according to SS 145 Part 2).

(b) The degree of protection of the enclosure shall be of minimum IP44 to SS IEC 60529.

(c) The enclosure can be of floor standing or wall mounting and shall be totally enclosed with all live parts protected from direct contact. Floor standing socket-outlet assembly shall be:-

- Fitted with supports to afford a minimum clearance of 150mm from the ground; and
- Provided with handles and lifting lugs.

(d) Every cable connection to and from the enclosure shall be means of plugs and socket-outlets as specified in subclause 5.5 of CP 88.

Single-phase socket-outlet assembly fed from single-phased source

(a) The assembly shall be fed from a 32A single-phase 230V source.

(b) A fixed plug rated at 32A single-phase 230V shall be provided to receive the 32A single-phase 230V incoming supply. A 32A double-pole MCB shall be provided to control the incoming supply.

(c) A maximum of up to six numbers of 16A 2-pole and earth socket-outlets shall be provided. Each socket-outlet shall be controlled by a double–pole MCB not exceeding 16A current rating. All socket-outlets shall be protected by residual current circuit breaker complying with Singapore Standard SS 97 having a rated residual current not exceeding 30mA.

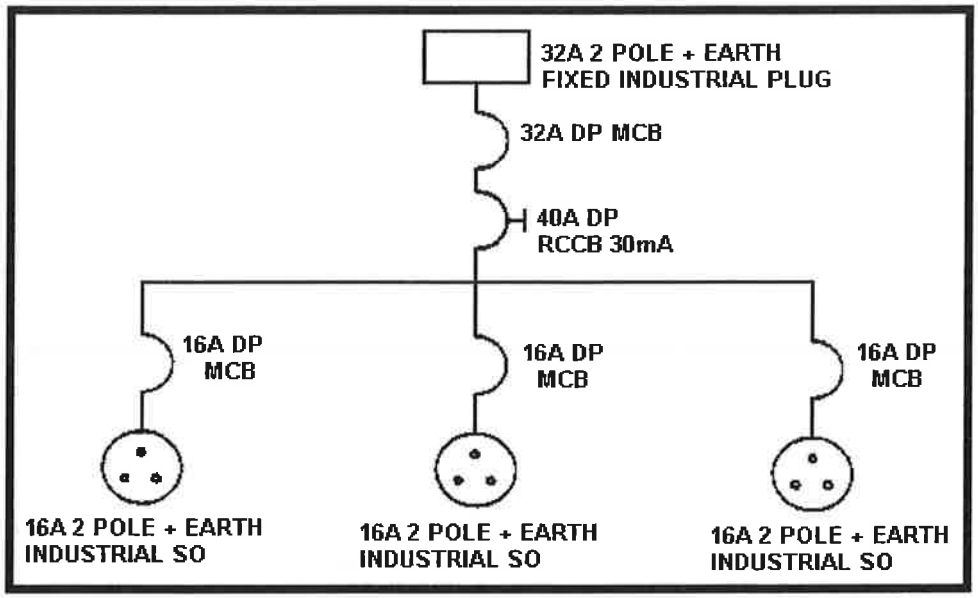


Figure 13 – Example of single-phase socket-outlet assembly fed from single-phase source

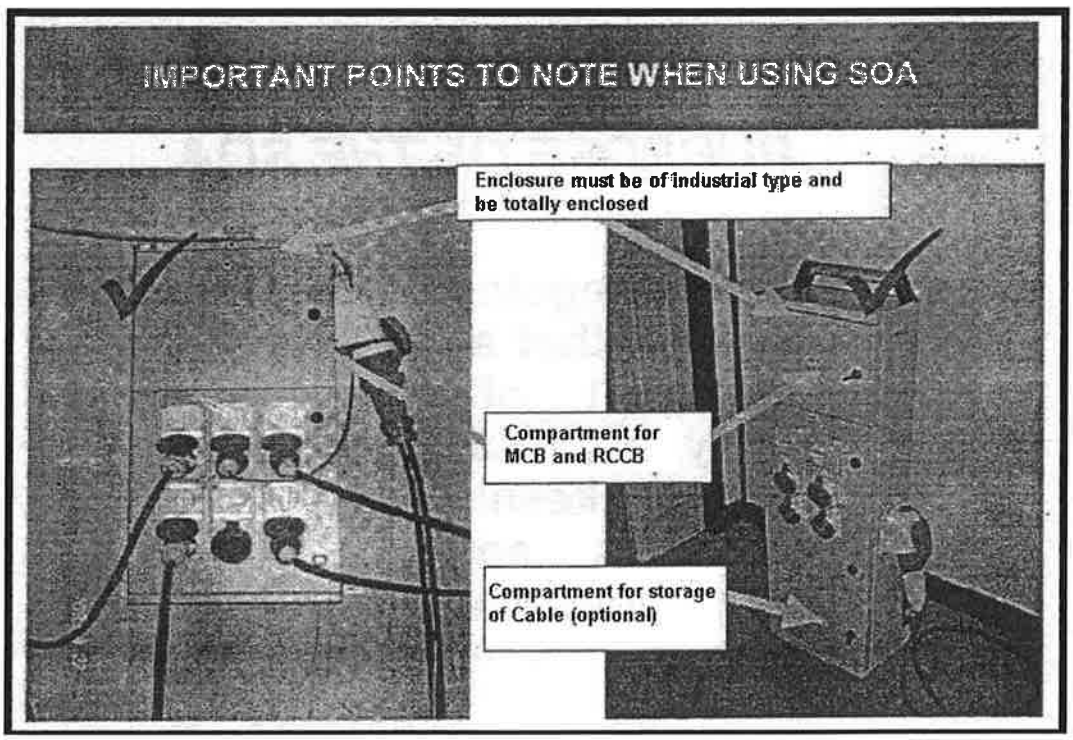


Figure 14 – Typical wall mounted SOA

Single-phase socket-outlet assembly fed from three-phase source

(a) The assembly shall be fed from a 32A three-phase 400V source.

(b) A fixed plug rated at 32A three-phase 400V shall be provided to receive the 32A three-phase 400V incoming supply. A 32A 4-pole MCB shall be provided to control the incoming supply.

(c) A maximum of nine numbers of 16A 2-pole and earth socket-outlets shall be provided. Each socket-outlets shall be controlled by a double-pole MCB not exceeding 16A current rating. All socket-outlets shall be protected by residual current circuit breaker complying with Singapore Standard SS 97 having a rated residual current not exceeding 30mA.

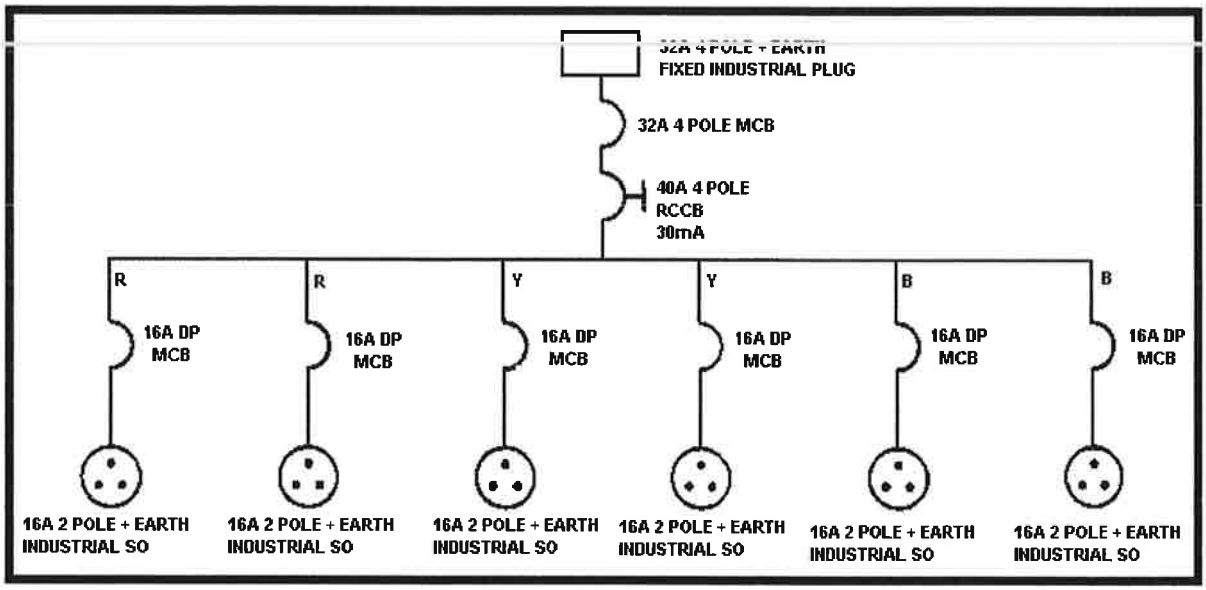


Figure 15 – Example of single-phase socket-outlet assembly fed from three-phase source

Three-phase socket-outlet assembly

(a) The assembly shall be fed from a 32A three-phase 400V source.

(b) A fixed plug rated at 32A three-phase 400V shall be provided to receive the 32A three-phase 400V incoming supply. A 32A 4-pole MCB shall be provided to control the incoming supply.

(c) A maximum of three numbers of 16A 4-pole and earth socket-outlets shall be provided. Each socket-outlet shall be controlled by a TP&N MCB not exceeding 16A current rating. All socket-outlets shall be protected by residual current circuit breaker complying with Singapore Standard SS 97 having a rated residual current not exceeding 30mA.

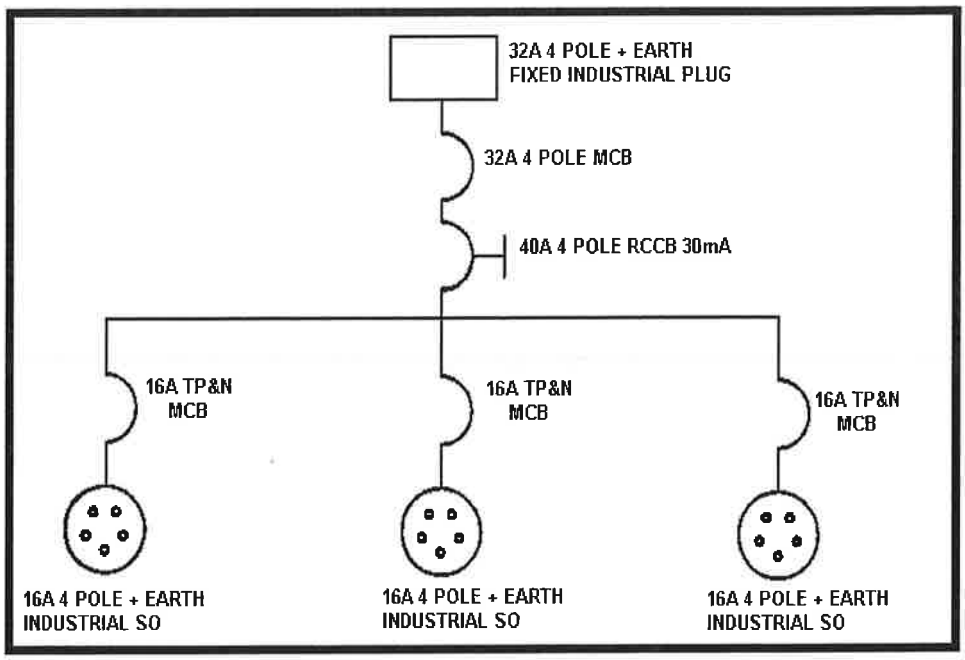


Figure 16 – Example of three-phase socket-outlet assembly

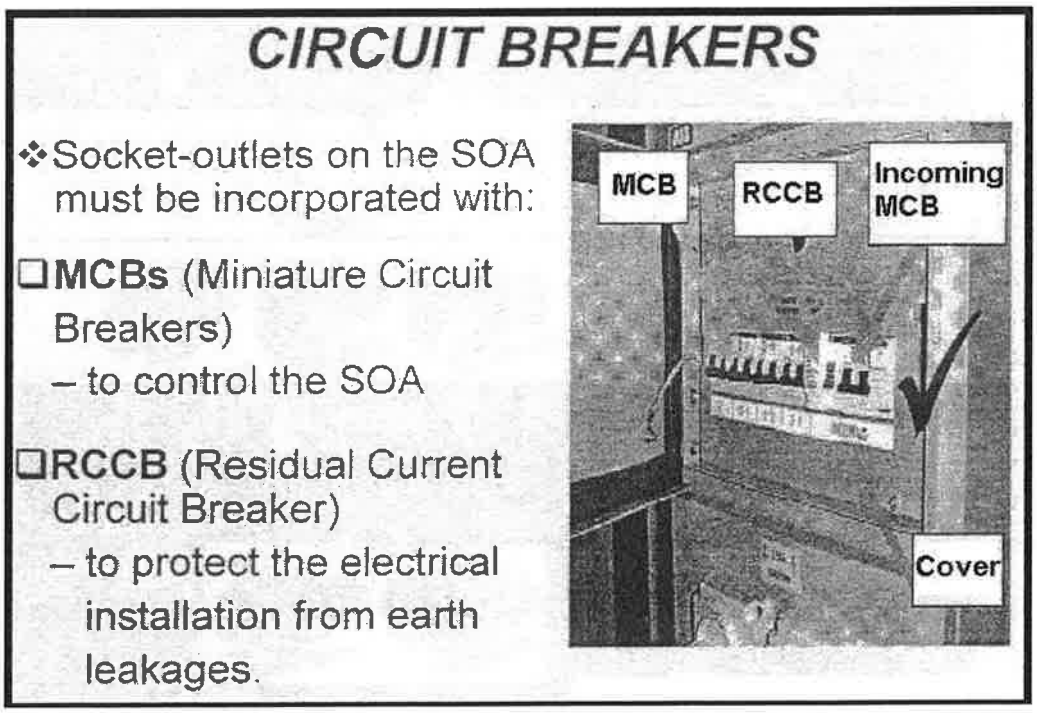


Figure 17 – Circuit breaker inside the SOA

Three-phase and single phase socket-outlet assembly

(a) The assembly shall be fed from a 32A three-phase 400V source.

(b) A fixed plug rated at 32A three-phase 400V shall be provided to receive the 32A three-phase 400V incoming

supply. A 32A 4-pole MCB shall be provided to control the incoming supply.

(c) A maximum of two numbers of 16A 4-pole and earth socket-outlets and a maximum of three numbers of 16A 2-pole and earth socket-outlet shall be provided. Each socket-outlet shall be controlled by a TP&N MCB/double-pole MCB of current rating not exceeding 16A. All socket-outlets shall be protected by residual current circuit breaker complying with Singapore Standard SS 97 having a rated residual current not exceeding 30mA.

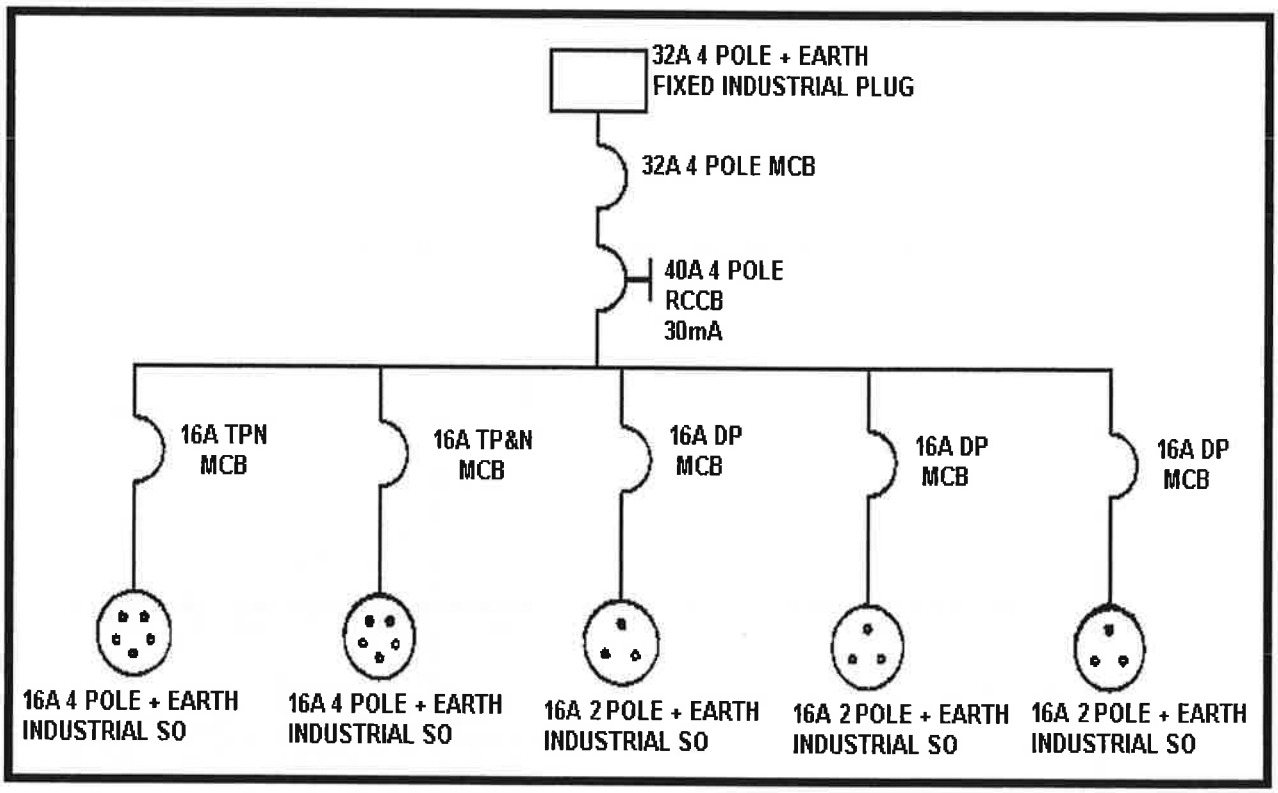


Figure 18 – Example of three-phase and single-phase socket-outlet assembly

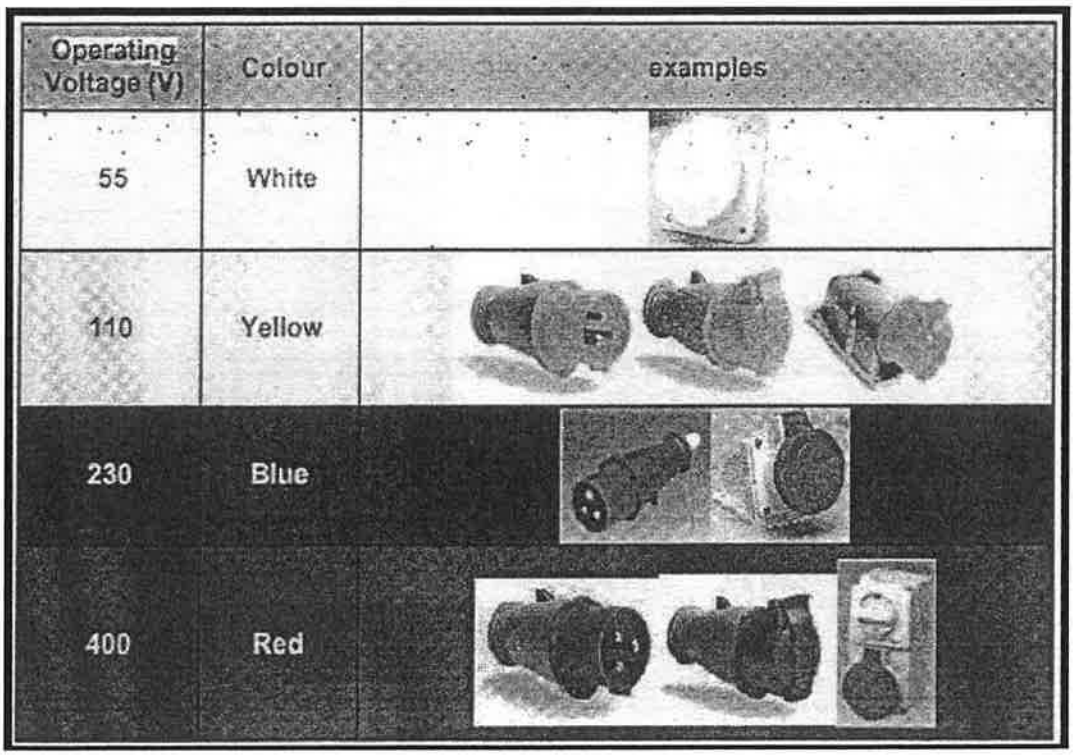


Figure 19 – Plug and socket-outlet on SOA

Plugs, socket-outlets and cable couplers

(a) All plugs, socket-outlets and cable couplers shall comply with the requirements of IEC 60309.

(b) All plugs, socket-outlets and cable couplers likely to be exposed to the weather shall be contained in a weatherproof enclosure unless they are of the weatherproof type (minimum IP44 to SS IEC 60529).

(c) Plugs of one voltage system shall not be capable of entering socket-outlets of other voltage systems used in the same site.

(d) Plugs, socket-outlets and cable couplers of a 110V single-phase operation shall be of the 3-pin and the 'numbered hour position' shall be 4H.

NOTE – Numbered hour position indicates the position of earth contact-tube in relation to the keyway.

(e) Plugs, socket-outlets and cable couplers for use with 230V single-phase system shall be of the 3-pin type with the numbered hour position 6H.

(f) Plugs, socket-outlets and cable couplers for use with 400V three-phase system shall be of the 5-pin type, 3-pole and neutral and earth, and numbered hour position 6H.

(g) Where several voltages are used in the temporary installation, all plugs, socket-outlets and cable couplers shall be identified by different colours as given in Table 2.

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

Table 2 – Colour coding

9.11 Connection to socket-outlets

(a) Connection of flexible cables or flexible cords to socket-outlets shall be by means of plugs.

(b) Where heavy electrical plants such as rail-mounted tower cranes requires the use of plugs and socket-outlets as a convenient form of connection at mains, such plugs and socket-outlets shall be mechanically interlocked. Electrical interlock can be used as an additional feature.

9.12 Cable for SOA Connection

An extension cable may be used to connect portable equipment to a SOA and such extension cable shall comply with the following conditions:

(a) the cable shall be appropriately sized and provided with suitable mechanical protection;

(b) the cable shall be connected to an industrial plug of appropriate rating on one end and a switched industrial socket-outlet at the other end to facilitate emergency switching; and

(c) the industrial plug and switched socket-outlet shall be as specified in clause 5.5 of CP 88.

9.13 Earthing arrangement and protective conductor

Every earthing arrangement and protective conductor shall be selected and erected to comply with the requirements of the Singapore Standard CP 5. Attention shall also be paid to the need for equipotential bonding of extraneous metallic parts.

(a) **Protective earthing of metalwork**

Metalwork not belonging to the installation including steel scaffolding which is liable to come into fortuitous contact and become live in the event of a failure of insulation of the installation shall be effectively earthed at all times.

(b) **Earthing of portable appliances and tools**

Exposed metalwork of all portable appliances and tools shall be connected to the circuit protective conductors in the flexible cables or flexible cords unless they are double-insulated as specified in SS 236 or of extra-low voltage system. For further guidance, refer to the appropriate clause in Singapore Standard CP 16 on earthing of portable appliances and tools.

(c) **Earthing of metal sheath and armour of cables**

Metal sheath and armour of cables shall be effectively earthed. However, the metal sheath or armour of the cable shall not be used as circuit protective conductor.

(d) **Metal sheath and/or armour of flexible or trailing cables**

Metal sheath and/or armour of flexible or trailing cables shall not be the sole circuit protective conductor but in addition to the earth cores of the cables.

(e) **Earthing of metal enclosure for switchboards and distribution boards**

Constructional precautions shall be taken to ensure electrical continuity between the exposed conductive parts of the switchboard and distribution boards and between these parts and the protective circuits of the installation.

9.14 Other equipment

(a) **Light fixtures**

Light fixtures used outdoor or at locations where there is likelihood that such fixtures are subjected to water splashing shall be of the weatherproof type. Light fixtures installed shall be

equipped with suitable guards if they are exposed to risk of mechanical damage.

(b) **Portable hand-lamps**

Portable hand-lamps supplied through flexible cords shall be of the moulded composition or other type designed for the purpose and equipped with a handle. Hand-lamps shall also be equipped with substantial guard attached to the lampholder or the handle.

(c) **Prohibited use of lampholders fitted with pin contacts**

The use of lampholders fitted with pin contacts intended to be penetrated into tough rubber sheath or polychloroprene sheath cable is prohibited.

(d) **Electrical welding system**

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

The low voltage shock preventors shall be of the built-in type or be housed in a weatherproof metal casing and effectively secured or locked to prevent tampering by welders and other unauthorized persons. The workpiece should be connected to the return terminal of the welding set through a proper return conductor.

9.15 Equipment for reduced voltage system

(a) **Plug, socket-outlet and cable coupler of a reduced voltage system**

Every plug, socket-outlet and cable coupler of a reduced voltage system shall have a protective conductor contact and shall not be dimensionally compatible with any plug, socket-outlet or cable coupler for use at any other voltage or frequency in the same installation.

(b) **Switches for reduced voltage circuits**

Switches controlling single-phase supplies on installations operating up to and including 110 V shall be of the double-pole type with circuit protection provided in each line conductor.

9.16 Inspection, testing and maintenance

(a) Electrical installation on site shall be inspected and tested in accordance with the requirements of Part 7 – Inspection and

Testing of Singapore Standard CP 5 before installation is energised.

(b) Strict maintenance and periodic inspection of the electrical installation and the wring distribution system shall be carried out by a skilled person to promote safety and to ensure efficient operation.

(c) All temporary electrical installations shall be inspected by a skilled person at least once a month. Upon completion of the inspection, the skilled person shall complete and sign the checklist shown in Annex C and hand it over to the operator of the electrical installation or his representative.

(d) Where any defect or unsafe condition is revealed during the inspection, the skilled person shall take measures, such as by rectifying the defects, or by isolating or disconnecting the defective part or parts from electricity supply, to render the electrical installation safe. Appropriate measures taken shall be clearly indicated in the checklist.

10 Introduction to SS CP88: Part 2: 2004

10.1 Introduction

This Part of the Singapore Standard CP 88 was prepared by the Technical Committee on Temporary Electrical Installations under the direction of the Electrical Industry Practice Committee.

Temporary electrical installations for festive lighting, trade-fairs, mini-fairs and exhibition sites such as bazaar, exposition and decorative lighting installation erected in conjunction with festive, religious or commercial events, are becoming increasingly common. This Code has been prepared to meet the need. It is drawn up to supplement the general requirements of Singapore Standard CP 5 – 'Electrical installations' and includes recommendations with regard to inspection, testing and maintenance.

In preparing this Code, reference was made to the IEC 60364-7-740 – 'Electrical installations of buildings, Part 7: Requirements for special installations or locations, Section 740 : Temporary electrical installations for structures, amusement devices and booths at fairgrounds, amusement parks and circuses' and SS 263 – 'Specification for luminaires, Part 10 : Particular requirements for lighting chains.'

The Technical Committee on Temporary Electrical Installations would also like to acknowledge the contribution of an initial draft by the Technical Committee on Festive Lighting.

Note – Temporary electrical installations other than that for festive lighting, trade-fairs, mini-fairs and exhibition sites may be covered in other parts of this Code.

10.2 Scope

This part of the Code deals principally with outdoor electrical installation set up for the provision of electricity supply for:

(a) trade-fairs or mini-fairs;

(b) exhibition;

(c) amusement park;

(d) decorative lighting in public place; or

(e) any outdoor electrical installation set up for festive, religious or commercial event accessible to the public.

It specifies the minimum electrical installation requirements to facilitate the safe design, installation and operation of mobile and temporarily installed electrical machines and structures, which incorporate electrical equipment. The machines and structures are intended to be installed repeatedly, without loss of safety, temporarily or permanently, at fair/exhibition sites, amusement parks or any other similar sites.

This Code does not cover decorative lighting within domestic premises as the requirement is provided by Singapore Standard CP 5.

However, some temporary installations may receive supplies at voltages higher than 1000 V, such parts of the installations are outside the scope of this Part of the Code.

Discharge lighting installation operating at high voltage for the purpose of decoration is also outside the scope of this code.

This code does not apply to the electrical equipment of machines.

NOTE – The titles of the publications referred to in this standard are listed at the end of the standard.

10.3 Objective

The objective of this Code is to ensure safety, especially protection against electric shock in the use of electricity in outdoor electrical installations, typically for festive lighting, trade-fairs, mini-fairs and exhibition sites, which are in open areas easily accessible by the public and subject to environmental conditions.

This Code is drawn up to supplement the general requirements of Singapore Standard CP 5.

The requirements of this Code are given in general terms, and will normally need to be supplemented by the advice of skilled persons.

11 Salient points of the SS CP 88: Part 2

11.1 Source of supply

- Public electricity supply network
- Generating sets

11.2 Types of supply

11.3 Supply voltage

- Reduced voltage
- Extra low voltage
- Separated extra-low voltage (SELV)

11.4 Type of earthing arrangement

- Generating sets – TN-S

11.5 Installation of generating set

- General
- Earthing
- Protection against direct contact to live parts
- Labelling on generating set

11.6 Protection for safety

11.7 Protection by residual current device

Protection against indirect contact shall be afforded using residual current devices and the following condition shall be fulfilled as appropriate to the type of earthing system:

For TN-S system: $Z_s I_{\Delta n} \leq 25$ V

Where:

Z_s is the earth fault loop impedance in ohms

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

For TT system: $R_a I_{\triangle n} \leq 25$ V

Where:

R_a is the sum of the resistances of the earth electrode and the protective conductor or conductors connecting it to the exposed-conductive-part.

11.8 Protection by residual current device for final circuits

Except for final circuits supplying equipment which are protected by other appropriate measures as permitted under this Code and only accessible to and are operated by a skilled person, all other final circuits are to be protected by one or more residual current devices. The type and tripping sensitivities of residual current device to be used for the final circuit of the following rating shall be:

(a) Residual current circuit breaker with a tripping current not exceeding 30mA and a tripping time within 0.1s complying with SS 97 for final circuits of rating not exceeding 63 A three-phase or single-phase at mains voltage.

(b) Residual current circuit breaker with a tripping current not exceeding 300mA complying with SS 97 for final circuits of rating exceeding 63 A but not more than 100 A three-phase or single-phase at mains voltage.

(c) Residual current device with a tripping current not exceeding 500mA shall be used for final circuits of rating exceeding 100 A three-phase at mains voltage.

11.9 Earthing of metal structures

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 CP 5 and the following clauses in this Section.

11.10 Wiring system

Installation of cables

(a) All cables shall meet the requirements of IEC 60332-1. Where appropriate, cables shall be of flexible construction.

NOTE – Where enhanced performance is required, cables should meet the requirements of IEC 60332-3; where low smoke cables are needed, the minimum recommended performance is given in IEC 61034-2.

(b) Cables shall have a minimum voltage designation of 450/750 V, except that, within amusement devices, cables and cords having a minimum voltage designation of 300/500 V may be used.

(c) Armoured cable or cables protected against mechanical damage 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.

(d) The routes of cables buried in the ground shall be marked at suitable intervals. Buried cables shall be protected against mechanical damage.

(e) Cables shall not be run across public roads or walkways unless:

(i) Adequate protection of the cables is provided against mechanical damage; and

(ii) Such installation will not cause any obstruction or pose any danger to the public.

(f) Cables installed for fixed wiring within the area covered by tents shall not cause obstruction to the public.

(g) 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.

Electrical connections

Joints shall not be made in cables and cords, except where necessary as a connection to a circuit. Where joints are made:

(i) Cable couplers complying with the requirements of IEC 60309-2 shall be used; or

(ii) Connection units complying with SS 241 or equivalent IEC standards and installed in an enclosure with a degree of protection suitable to the environmental conditions but not less than IP 4X shall be used. If the enclosure cover can be removed without the aid of

tools or keys, the connections inside the enclosure shall be protected to at least IP 2X.

All cable coupler and connection units shall be supported above floor or ground level in such a manner that the risk of mechanical damage is prevented.

Where strain may be transmitted to terminals, cable anchorage shall be provided.

11.11 Devices for isolation and switching

(a) A means for isolation and switching shall be provided and readily accessible at every switchboard or distribution board for the purpose of disconnecting all phases, poles and the neutral.

(b) 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.

11.12 Switchgear and controlgear

(a) Enclosure for low-voltage assembly

(b) Switchboard and distribution board

11.13 Other equipment

(a) General requirements for equipment installed outdoor including tents

All switches, socket-outlets, distribution boards, or accessories such as junction boxes, ceiling roses, etc. shall be properly installed and suitable for the environmental conditions. All equipment or accessories, which are likely to be exposed to the weather or water splashing, shall have a degree of protection of minimum IP44 complying with SS IEC 60529 or shall be contained in weatherproof enclosures.

(b) Luminaires and fans

All luminaires, fans and decorative chains shall be securely attached to the structure or support intended to carry them. The supply cable shall not carry their weight unless it has been selected and erected for this purpose.

Luminaires and decorative chains mounted less than 2.5m (arm's reach) above floor level or otherwise accessible to accidental contact shall be firmly fixed, and so sited or guarded as

to prevent risk of injury to persons or ignition of materials. Access to the fixed light source shall only be possible by removing a barrier or an enclosure, a procedure that shall require the use of a tool.

(c) Lampholders

Insulation-piercing lampholders shall not be used.

(d) Lamps in shooting galleries

All lamps in shooting galleries and other sideshows where projectiles are used shall be suitably protected against accidental damage.

(e) Lighting chain

The lighting chain shall comply with the requirements specified in Part 10 of SS 263.

(f) Floodlights

All floodlights shall be mounted so that the luminaire is inaccessible to the public. The supply cables shall be flexible and adequate mechanical protection shall be provided.

(g) Fire risks for luminaires and floodlights

Luminaires and floodlights shall be so fixed and protected that a focusing or concentration of heat is not likely to cause ignition of any material.

(h) Electrical discharge lamp installations

Every installation of luminous tube, signs or lamps on a booth, stand or amusement device with an operating voltage higher than 230/400 V A.C. shall comply with the requirements of BS 559.

(i) Location

The sign or lamp shall be installed out of arm's reach (more than 2.5m above floor) or shall be adequately protected to reduce the risk of injury to persons.

(ii) Installation

The fascia or material behind luminous tube, signs or lamps shall be non-ignitable.

Controlgear with output voltages higher than 230/400 V a.c shall be mounted on non-ignitable material.

(iii) Emergency switching devices

A separate circuit shall be used to supply such signs or lamps, which shall be controlled by an emergency switch. The switch shall be easily visible, accessible and marked in accordance with Singapore Standard CP 5.

(i) Safety isolating transformers and electronic converters

Multiple connection safety isolating transformers shall comply with IEC 61558-2-6 or provide an equivalent degree of safety.

A manually reset protective device shall protect the secondary circuit of each transformer or electronic converter (see IEC 60204-1).

Safety isolating transformers shall be mounted out of arm's reach of the public and shall have adequate ventilation. Access by skilled or instructed persons for testing and protective device maintenance shall be provided.

Electronic converters shall conform to IEC 61046.

Enclosures containing rectifiers and transformers shall be adequately ventilated and all vents not obstructed when in use.

(j) Overground or control boxes

Overground or control boxes shall preferably be made of high impact PVC or insulating material. The use of such material is to provide supplementary insulation to reduce risk of overground or control boxes becoming live in the event of fault.

Overground or control boxes that housed the circuit breakers, socket-outlets, etc for the purpose of distributing supply shall be suitable for environmental conditions.

(k) Socket-outlets, plugs and couplers

An adequate number of socket-outlets shall be installed to allow the user's safety requirements to be met.

All socket-outlets shall be firmly installed and suitable for the environment. Socket-outlets, plugs and couplers that are likely to be exposed to weather conditions shall comply with IEC 60309-2 or contained in weatherproof enclosures.

Not more than one flexible cable or cord shall be connected to a plug unless the plug is specifically designed for multiple connections.

Multiple-way plug-in type adapters shall not be used.

11.14 Decorative lightings

(a) Definition of decorative lighting

- Locations
  - Outdoor
  - Indoor
- Voltage level
  - Low voltage system (230/400 V)
  - SELV (<25 V AC RMS or 60 V ripple-free DC)
    - For lighting accessible/within reach/accessible to accidental contact, it shall be SELV operated.
- Type of luminaries

(b) Section 5.6 decorative lighting of CP 88 part 2

- Decorative lighting can be operated at either low voltage or SELV
- Protection by residual current circuit breaker of 30mA sensitivity for each decorative lighting circuit
- Protection by SELV not exceeding 25 V (AC RMS) or 60 V (ripple –free DC)

(c) Selection of decorative lighting

CP 88 Part 2
Section 5.5(other equipment)

5.5.1 General requirement

- Suitable for the application environment
- Min. IP 44 (lightly exposed to weather/water splashing) or in weatherproof enclosures

5.5.2 Installation

- Securely attached to structure or support
- Supply cable carry the fitting if designed for

- Sited/guarded to prevent risk of injury/ignition of material (if it is mounted less than 2.5m height)
- Protected by barrier/enclosure and access by tool only (if it is mounted less than 2.5m height)

5.5.6 Floodlights

- Inaccessible to the public
- Supply cable for floodlight shall be flexible /mechanical protection
- Position of floodlights to avoid focus or concentration of heat to cause ignition of any materials

5.5.8 Discharge lamp (>230/400 V A.C)

- Installed 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

11.15 Inspection, testing and maintenance

(a) Electrical installation on site shall be inspected and tested in accordance with the requirements of Part 7 – Inspection and Testing of Singapore Standard CP 5 before installation is energised.

(b) Strict maintenance and periodic inspection of the electrical installations and the wiring distribution system shall be carried out by a skilled person to promote safety and ensure efficient operation.

(c) All temporary electrical installations shall be inspected periodically by a skilled person. Upon completion of the inspection, the skilled person shall complete and sign the checklist shown in Annex B and hand it over to the operator of the electrical installation or his representative.

(d) Where any defect or unsafe condition is revealed during the inspection, the skilled person shall take measures, such as by rectifying the defects, or isolating or disconnecting the defective part(s) from electricity supply, so as to render the electrical installation safe. Appropriate measures taken shall be clearly indicated in the checklist.

12 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.

Solar PhotoVoltaic

Name
Designation
Housing & Development Board
Building Research Institute

Contents

1. Types of Solar PV
2. Installation of Solar PV system
3. Solar PV system
4. Solar PV on rooftop
5. Large Solar Installation
6. Lightning Protection requirements
7. Inspection before connecting to power grid
8. Maintenance

Types of Solar



- **Solar – Available all year round**

  2 Types

  - **Thermal – Use for heating**
    - **eg water heater**
  - **Photovoltaic**
    - **– generate electricity**





3

Different Types of Solar Cell/Modules

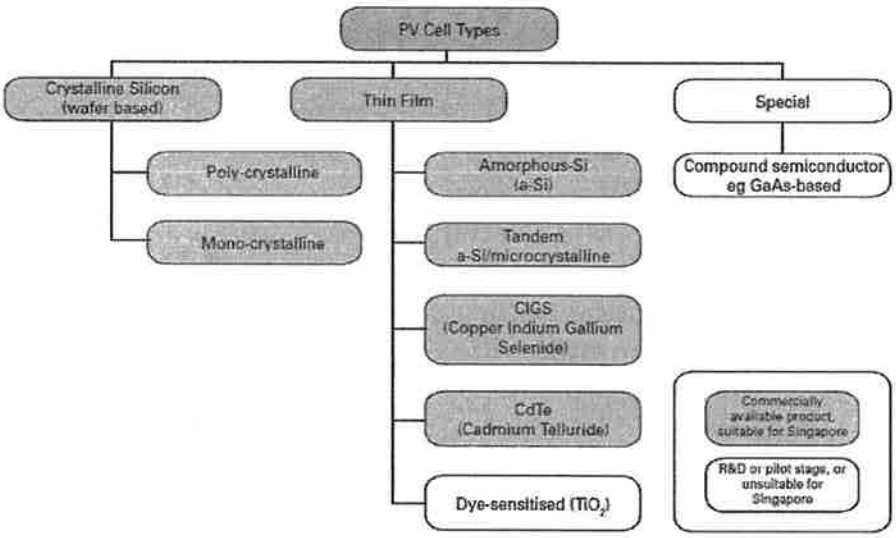


Figure 5. PV technology family tree

4

Types of Modules





Mono-crystalline silicon



Poly-crystalline silicon



Thin-film



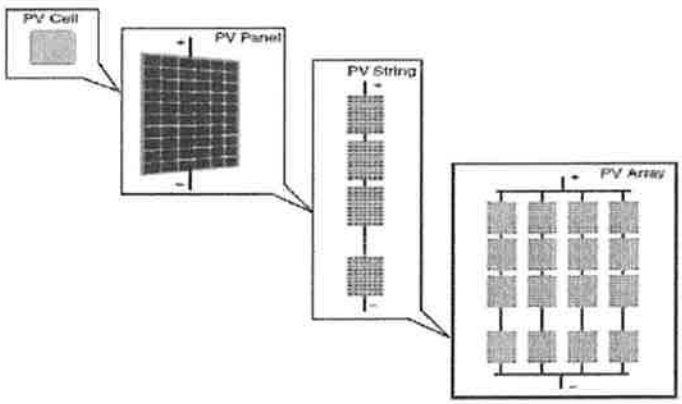
CIGS thin film

Common PV module technologies

5

Cells into Modules

- **Cells connected in series to form a module**



6

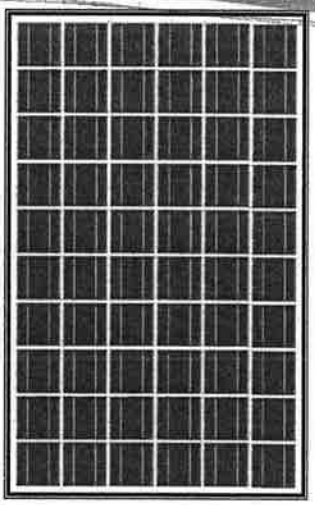
Solar Panel

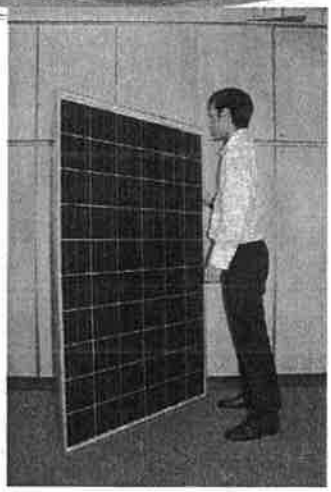


155 mm

155 mm

Single Cell





DC	10 x 6 = 60 cells	Panel size : 1.66 x 0.99 m
Volts per cell ~ 0.49V	0.49 V x 60 = 29.4 V	Weight : 20 kg
Watts per cell ~ 3.83W	3.83 W x 60 = 230 W	

7

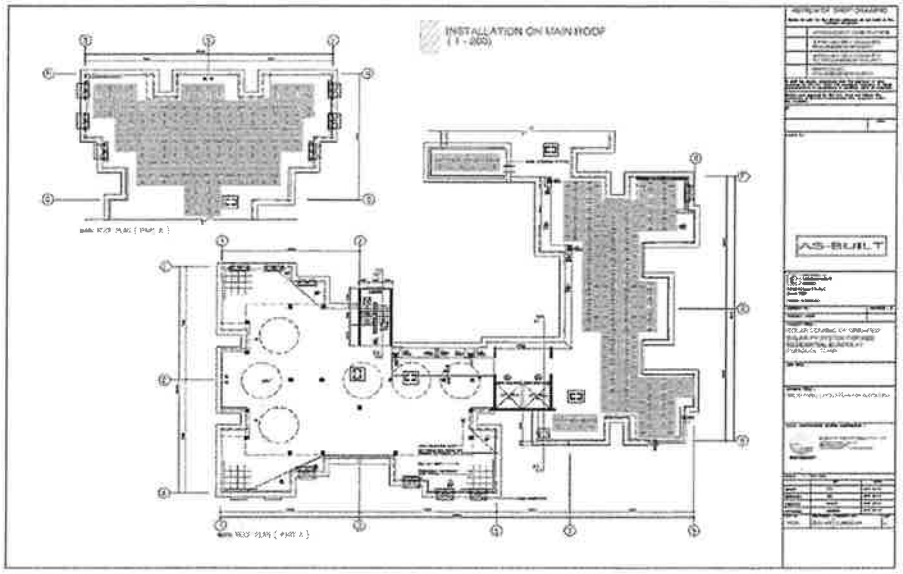
Solar on HDB Roof





Typical HDB Roof ~ 40-50 kWp

8



9

Installation of Solar PV system

- **Electrical Installation**
  Conversion to Dc to AC
- **Structural Requirements**
  Support for PV
- **Electronic Monitoring**

10

Installation of Solar PV

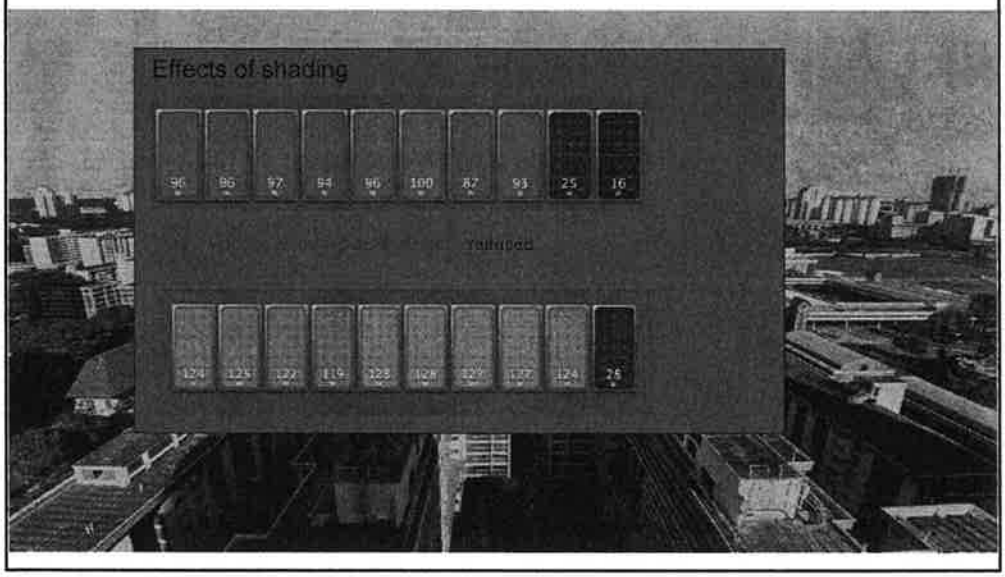
Factors to be considered

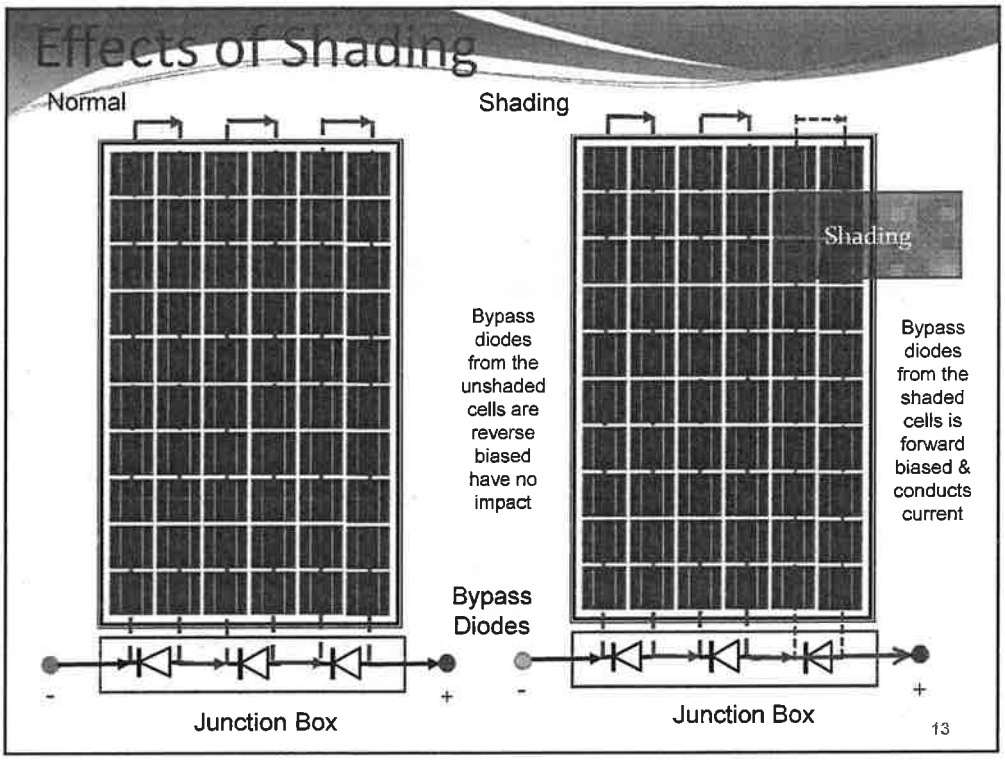
- Shading
- Structural Load
  - **Structure**
  - **Wind load & speed**
- Accessibility for maintenance
- Safety measures
- Balance of System
  - consist of all components of a renewable energy system except for the solar modules and their mounting system.

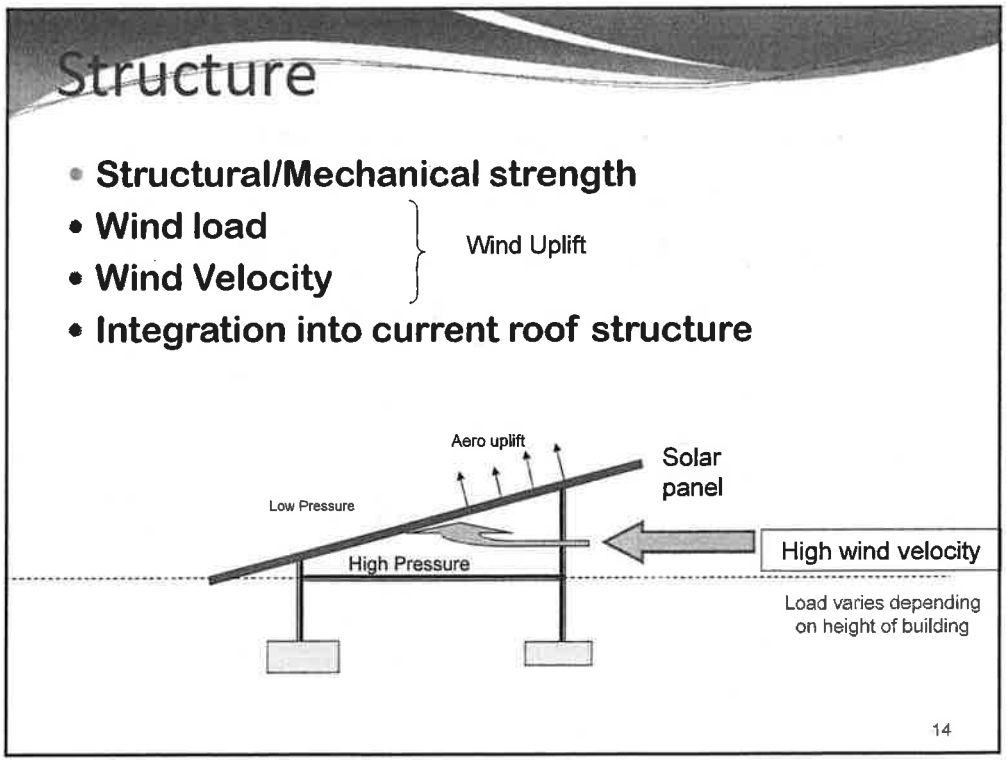
11

Site/location of the solar PV

- Effects of shading on solar pv string

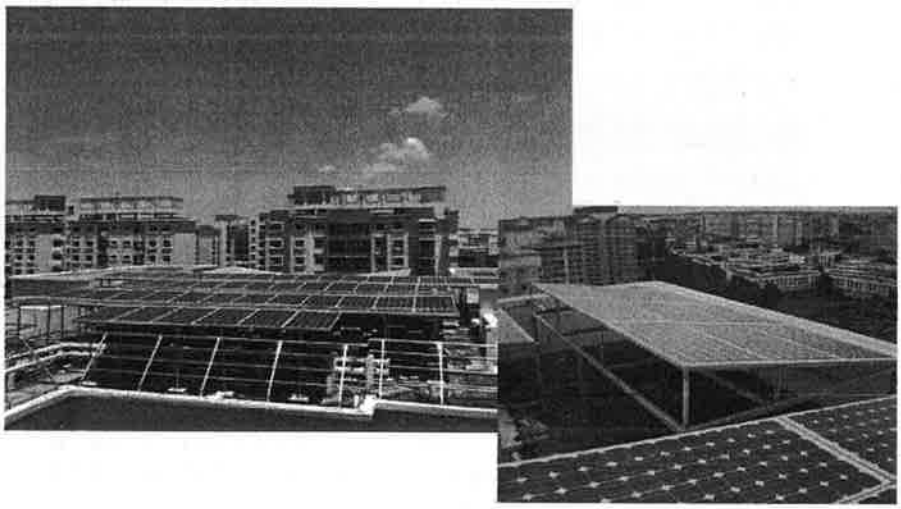



Effects of Shading
Normal
Shading
Shading
Bypass diodes from the unshaded cells are reverse biased have no impact
Bypass diodes from the shaded cells is forward biased & conducts current
Bypass Diodes
-
+
Junction Box
-
+
Junction Box
13


Structure
• Structural/Mechanical strength
• Wind load
• Wind Velocity
Wind Uplift
• Integration into current roof structure
Aero uplift
Solar panel
Low Pressure
High Pressure
High wind velocity
Load varies depending on height of building
14

Accessibility for Maintenance

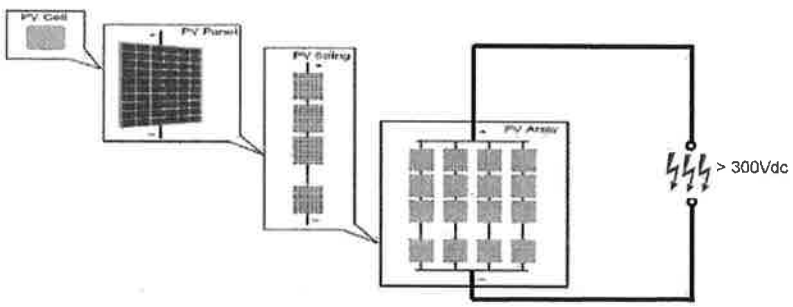
- Space for access of maintenance



15

Safety

- One cell very low voltage < 0.5V
- One module ~ 30V dc
- In array/string ≥ 300Vdc
- Inverter input 300 - 500Vdc



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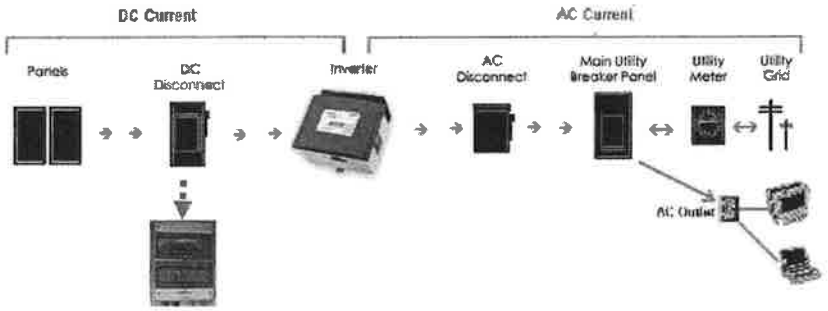
Balance of System

- **Balance of System components**
  - **all components of a renewable energy system except for the solar modules and their mounting system.**
  - **Inverters, fuse/breakers, overcurrent protection, enclosures, batteries, charge controller.**



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Choice of Installation Materials

1. **Support structure**
   - **Aluminum**
   - **Galvanized Iron**





2. **Solar Cables & Connectors, Junction boxes**
   - **Insulation – to withstand weather elements**
     - **Heat**
     - **Water**
     - **UV**



3. **Outdoor Installation**
   - **Exposed**
   - **Enclosed**



MC4

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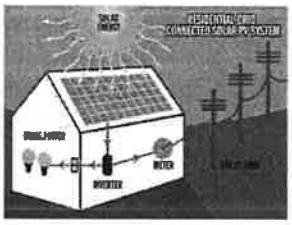
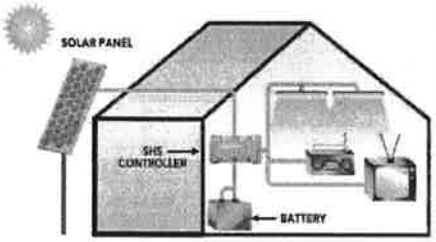
Types of Solar PV System

System – Scheme

- Grid-Tied system
- Off-Grid
  - Standalone
    - Battery (Deep Cycle)
- Hybrid System







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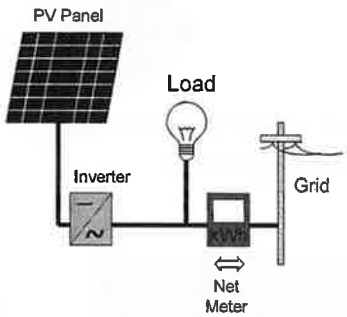
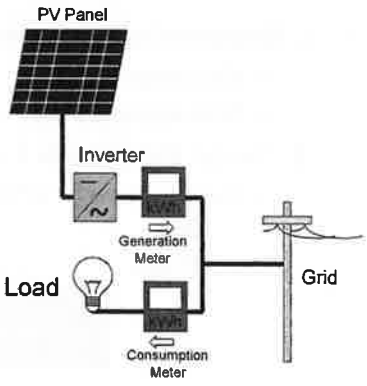
Net Metering & Feed-in Tariff





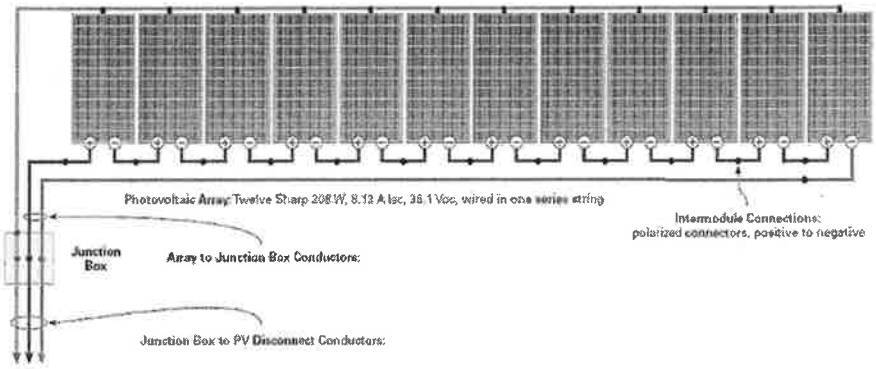
Net Metering

Feed-In Tariff

Above shows the typical meter connection for Net Metering & Feed-in Tariff.

20

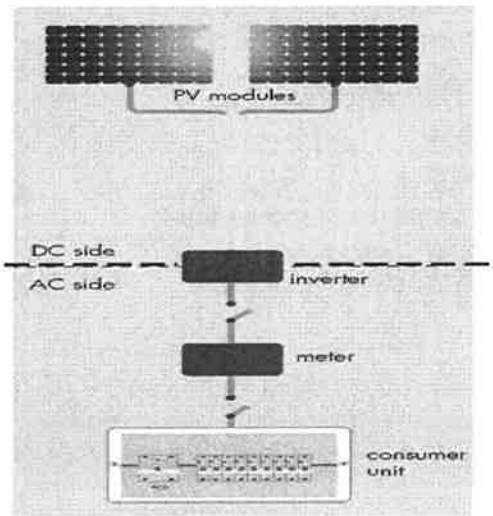
PV String



PV String Voltage : 36.1V x 12 modules = 433.2V

21

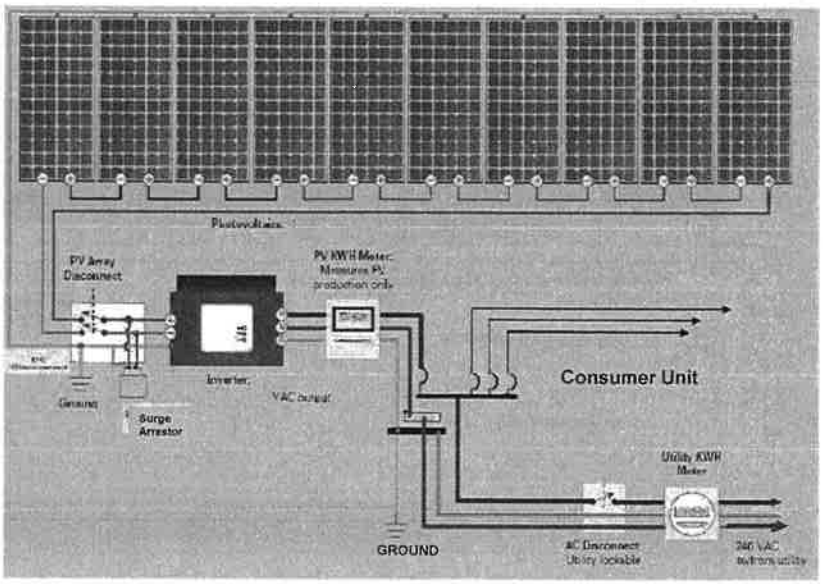
Components of Typical PV System



22

Schematic Diagram - Grid Tied Systems

Single Phase Inverter



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Inverters

- Compliance with local power service provider requirement – EMI, DC component
- Selection of Inverters
  - Matching
- Efficiency
  - Transformer/transformerless
- 'Islanding' effect





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Types of Solar Inverters

- Grid-tied
  - **MICRO-INVERTERS**
    - Located on the back of single solar panel.
    - Offers panel level MPPT
    - Higher cost per watt
  - **STRING INVERTERS**
    - Most common used
    - Up to <600 Vdc
    - 3-phase variation available
  - **CENTRAL INVERTERS**
    - Similar to string inverters designed for very large string arrays
    - Low capital cost per watt
    - from 100 kW up to 1000 kW

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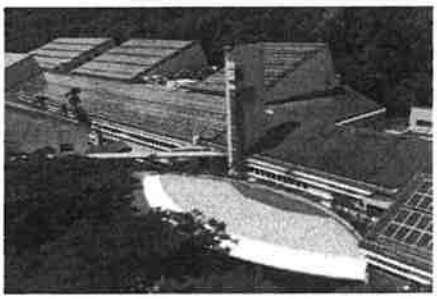
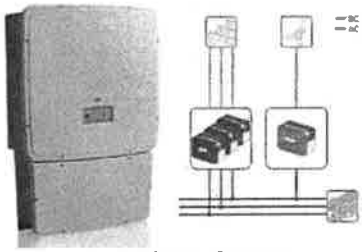
1 MWp single site installation



Singapore American School in Woodlands



3 Phase System

3-phase inverter

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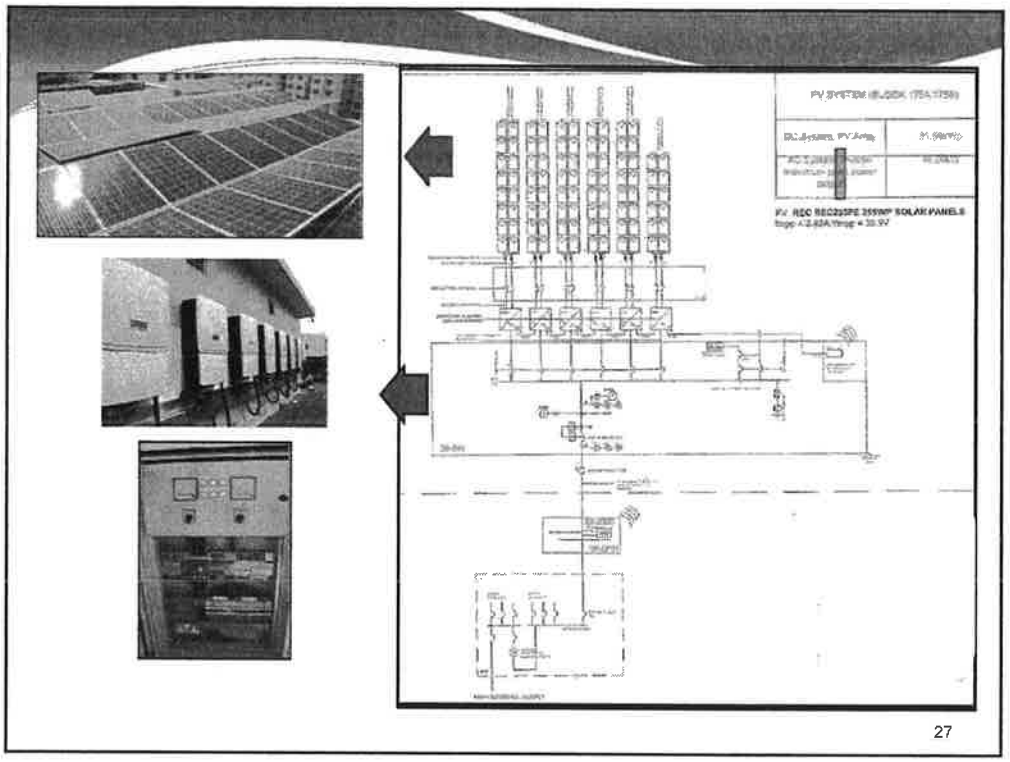

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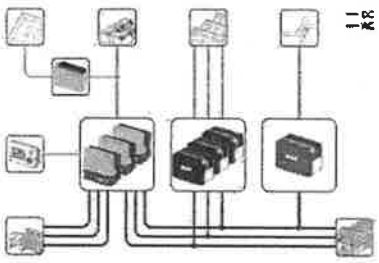
1 or 3-phase Solar Installation

1-phase

- 1-phase installation eg. home
- Capacity less than 5 kWp
- Inverters cost

3-phase

- Load Balance - feed evenly across all phases
- 3-phase installation bungalows commercial/industrial
- Inverter cost



3 Phase System

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Lightning Protection Requirements



- Lightning protection
  - Sufficient air terminals
- Bonding of the frame
  - to building LPS
- Surge arrestors



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Inspection before connecting to power Grid

- Safety
- Visual Check all termination
  - Polarity ; Earthing
- Earthing/Bonding continuity

Testing & Commissioning

a) **PV string open circuit voltage measurement**

b) **PV string current measurement**

Checklist

c) **Functional tests**
   I. DC and AC Disconnect
   II. Operational Mode of Inverters
   III. Loss of mains test

d) **Labelling and Identification**
   I. Inspect all circuits, protective devices, switches and terminals are suitably label for ease of identification.
   II. Single line diagram to be displayed inside the ACDB
   III. Ensure that all signs and labels are suitably affixed and durable

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Application Form to SP Services for Connection to Transmission System



APPLICATION FORM
FOR CONNECTION TO THE
TRANSMISSION SYSTEM

For official use only	
Application Number :	
Date Received :	

To : SP Services Ltd
111 Somerset Road #01-10
Singapore 238164

PART 1 APPLICANT'S DETAILS

All connections with Distributed Generation (e.g. PV system) are required to submit this application.

I request you to provide/upgrade the load connection service to my premises as given in Part 2 by my Licensed Electrical Worker undertaking the project

Name of Company/Applicant * : _____ ROC/NRIC No. : _____

Department / Sub-BU: _____
(Only applicable for Ministries & Statutory Boards for invoice through NSC)

Name of Authorised Person & Designation * : _____

Forwarding Address: _____ Postal Code: Singapore _____

Tel: _____ Fax: _____ Mobile Phone: _____ Pager: _____

Email: _____ Signature of Applicant: _____ Date: _____

PART 2 INSTALLATION DETAILS (To be completed by LEW)

Project Description: _____

Site Address: _____ Postal Code: Singapore _____

Utility Account No. (existing): _____ Existing Approved Load: _____ kV/MW *

Any previous Consultation? Yes / No* If Yes, please provide Consultation No.: _____

TYPE OF CONNECTION (Please tick the appropriate boxes)

☐ New Connection ☐ Temporary Connection ☐ Replacement of switchboard (no load upgrading / same / different switchgear *)

☐ New Connection with Distributed Generation (Please specify) _____

☐ Existing Connection with Distributed Generation (Please specify) _____

☐ Upgrading the existing connection point ☐ Change of mode connection point (existing new switchgear) ☐ Re-energise existing connection

☐ Others (Please specify) : _____

TYPE OF DEVELOPMENT (Please tick the appropriate boxes)

☐ Industrial ☐ Commercial ☐ Residential ☐ Renewable Energy

☐ Others (Please specify) : _____

Type of Business Activity (Brief Description) : _____ Voltage Dip Sensitive? Yes / No *

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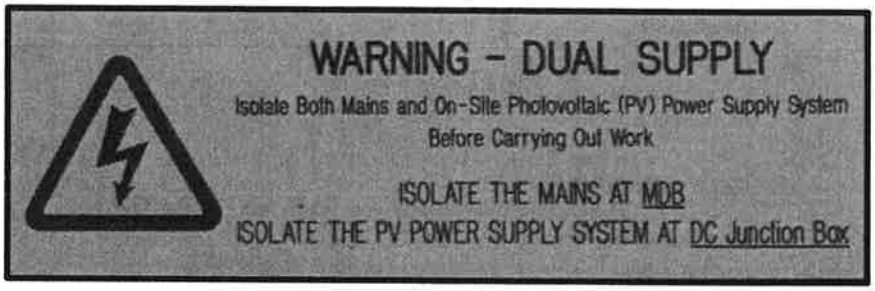
Inspection & Commissioning





Warning Label : Dual Supply



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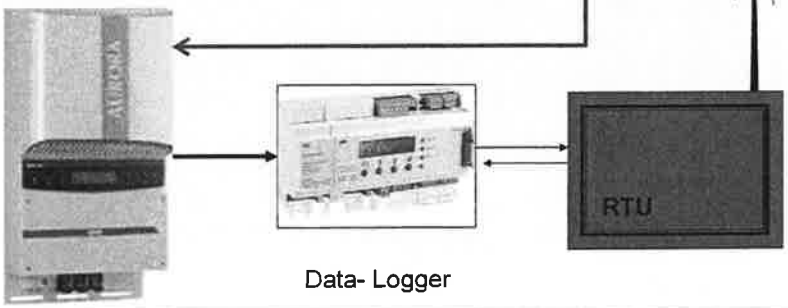
Maintenance

- Cleaning of PV panels
- Monitoring of Solar PV
  - Remote monitoring
    - Energy Generation
    - Weather
    - Breakdown/Fault





Data- Logger

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Reference

http://www.ema.gov.sg





Appendix C

C.1 CONTACT INFORMATION

For enquiries on the following matters pertaining to Solar PV systems, please contact:

(1)	Buildings issues	Building And Construction Authority (BCA)
(2)	Development Planning Control – Conserved Buildings	Urban Redevelopment Authority (URA) Building Conservation
(3)	Development Planning Control – Non-conserved Buildings	Urban Redevelopment Authority (URA)
(4)	Electricity Licences	Energy Market Authority (EMA)
(5)	Licensed Electrical Workers ("LEWs")	Energy Market Authority (EMA)
(6)	Electricity market rules, market registration, process, and market charges	Energy Market Company (EMC)
(7)	Connection to the power grid	SP PowerGrid Ltd (SPPG)
(8)	Connection to the power grid	SP Services Ltd (SPS)

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Testing & Commissioning Checklist for PV Installation

1 General visual inspection of module, structure & wiring installation

☐ Alignment ☐ Proper tightening ☐ Sturdy
☐ Good wire management ☐ Adequate cable ties

2 Measure the open circuit voltage (Voc) and short circuit current (Isc) of each string at the module side (compare against expected reading on Page 1)

Voc = _____ ☐ Polarity Isc = _____

3 Ensure all string connectors disconnected at trunking and at inverters side. Measure the insulation resistance of each PVC/PVC string cable

Insulation resistance = ...MΩ

Checklist

Array No : ..... **No. of Strings : .....**
No. of Modules Per String : .....

Module
Make / Model No : .....
Peak Power : ..... Vmpp : ..... Impp : ..... Voc : .....
Isc :
.....

String
Open circuit string voltage = No. of modules per string x Voc = ...
String operating voltage = No. of modules per string x Vmpp = ...

Inverter
Make / Model : ..... Serial
No : .....

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Checklist

4. Connect up the string connectors located in the trunking – i.e connect to the UV resistant cables to the PVC/PVC cables

   ☐ Correct polarity ☐ Proper engagement of connectors

5. Measure the Voc and Isc of each string via the MC4 connector at the inverter side (w/o plugging in the connector to the inverter) (compare against expected reading on Page 1)

6. Check live, neutral and earth connections from DB to isolator and from isolator to inverter. Measure the voltage at the DB incoming

   ☐ Proper tightening of connections Voltage: .....

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Inverter

1	Turn on the electronic DC switch	
2	Turn on the AC supply to the inverter	
3	Observe that the green LED turns on	
4	Observe that the LED display shows the PV power, voltage, etc after about one minute	
5	Record the following operational readings at the LCD screen of the inverter	Vdc: …… Vac:…… Pac :…… Idc: …… IAC: ……

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Labelling and Identification

a) Inspect all circuits, protective devices, switches and terminals are suitably label for ease of identification.

b) Single line diagram to be displayed inside the ACDB

c) Ensure that all signs and labels are suitably affixed and durable

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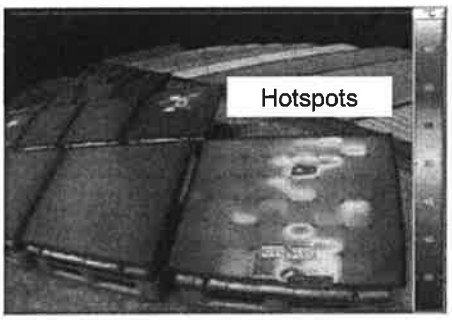
Shaded panel

- Hotspot on shaded panel





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Single Phase or 3-Phase Inverters

The main benefits of 3 phase solar inverters

- convert the solar power to AC power which is fed evenly into the property over all 3 phases.

Eg

5 kW single phase solar inverter working at maximum capacity would be feeding 5kW of solar power into one phase
but a 3-Ø; 5kW solar inverter in the
5 kW divided by 3 phases = 1.7 kW;
that's 1.7 kW of power feeding into each phase.

- For 6 kW and greater solar inverter systems
if all the power was feeding down one phase it may well be too much load on the single phase and create an unbalance between the loading of the phases. For solar power systems with inverters of 5kW in size or smaller this isn't generally an issue because 5 kW of power feeding down 1 phase is not usually a problem. I say not usually a problem as sometimes smaller solar power systems between 3 to 5 kW do require a 3 phase solar inverter.

* Price(Cost)

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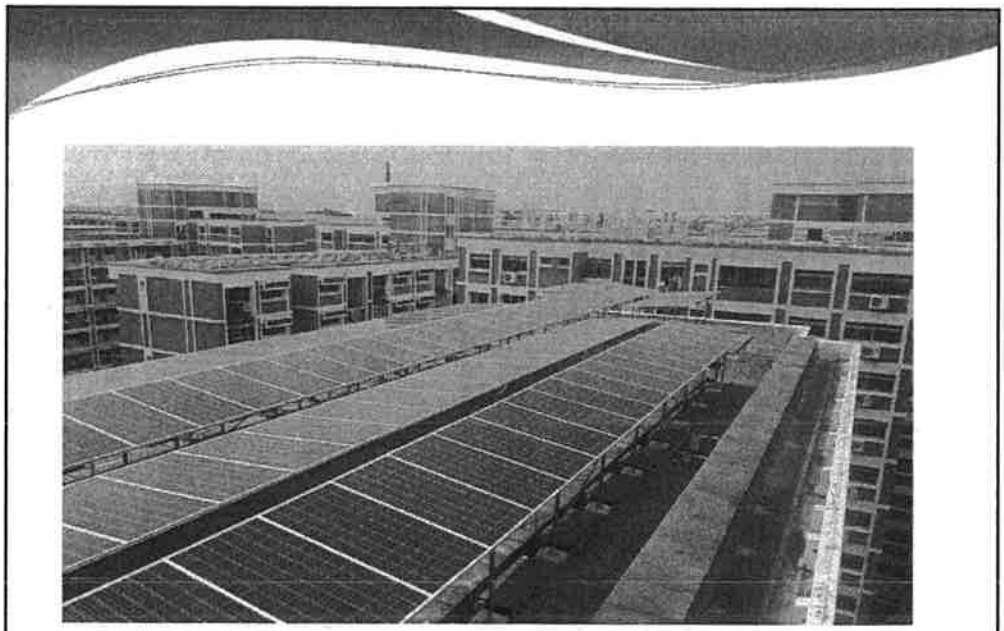


TOPIC 8: ELECTRICAL ACCIDENT INVESTIGATIONS – CASE STUDIES

Case Study 1

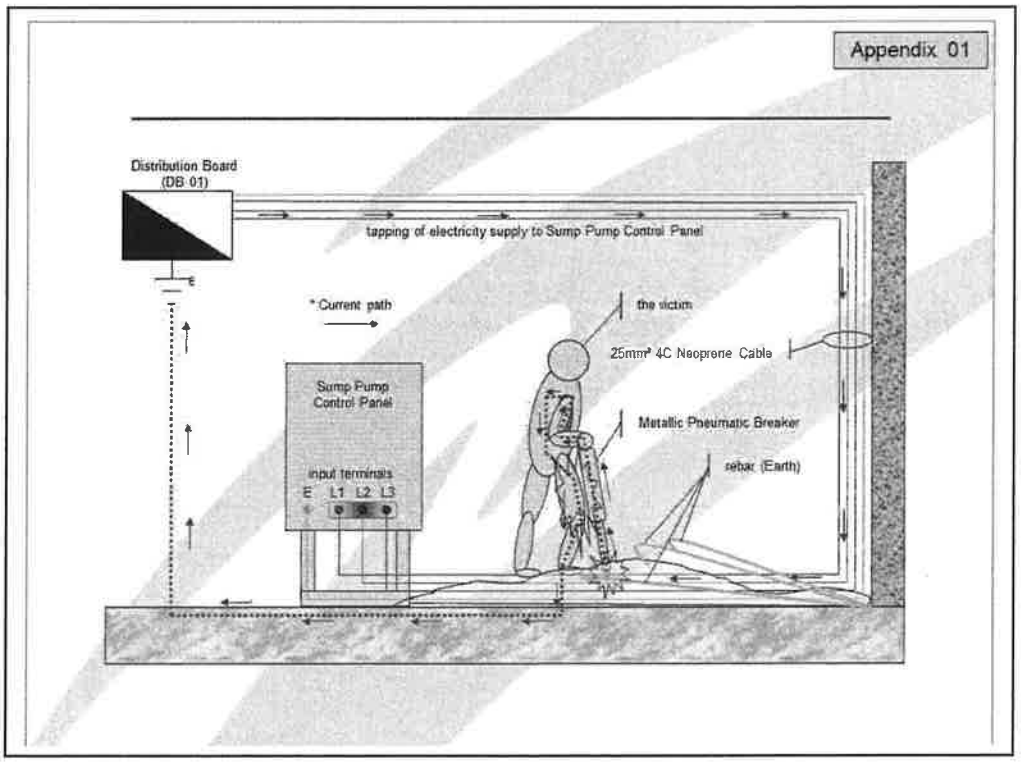
1.1 Background

Two construction workers were assigned to carry out works using a pneumatic breaker to hack & remove construction cement debris in an underground work area within the construction worksite.

During the course of work, one of the construction workers received an electric shock. The paramedic pronounced him dead on the same day after the incident.

1.2 Investigation and findings

The underground work area was wet and damp, a 25mm² neoprene cable was found dangling from the wall and part of the cable was covered under the construction cement debris. The cable end was connected to the sump pump control panel (see Appendix 01). A metallic pneumatic breaker was found lying on the floor.

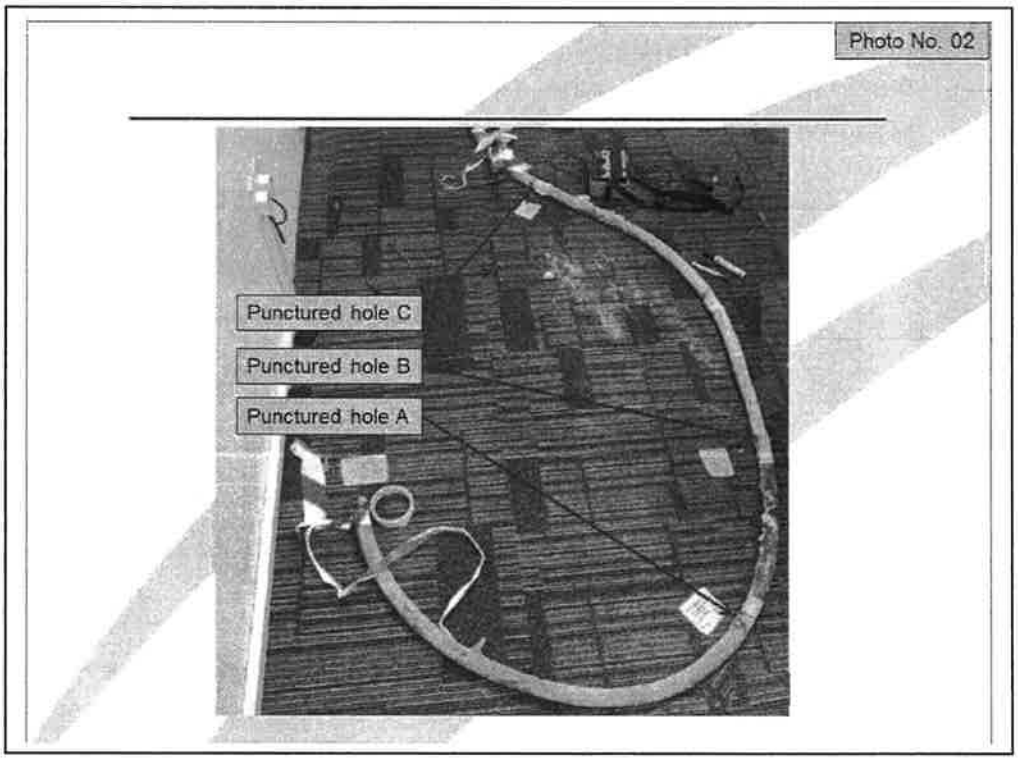


The electricity supply of the sump pump control panel was taken from a Distribution Board (DB-01) through the 25mm² neoprene cable. The incoming DB-01 was equipped with an incoming 3-pole 100A MCCB rated at 415V, and a RCCB rated at 100A with 100mA tripping sensitivity. Both the MCCB and RCCB were found in the "tripped" position.

Close examination was conducted on the 25mm² neoprene cable after it was carefully removed from the construction debris. It was found that:

a. There was three nos. of punctured holes on the neoprene cable and exposed metallic conductors could be seen as shown on Photos No. 02 & 03, labeled as punctured holes A, B and C;

b. There was a dented mark on the surface of a rebar found nearby, it could be caused by the chisel of the pneumatic breaker when the victim was carrying out the work (see Photo No. 04).



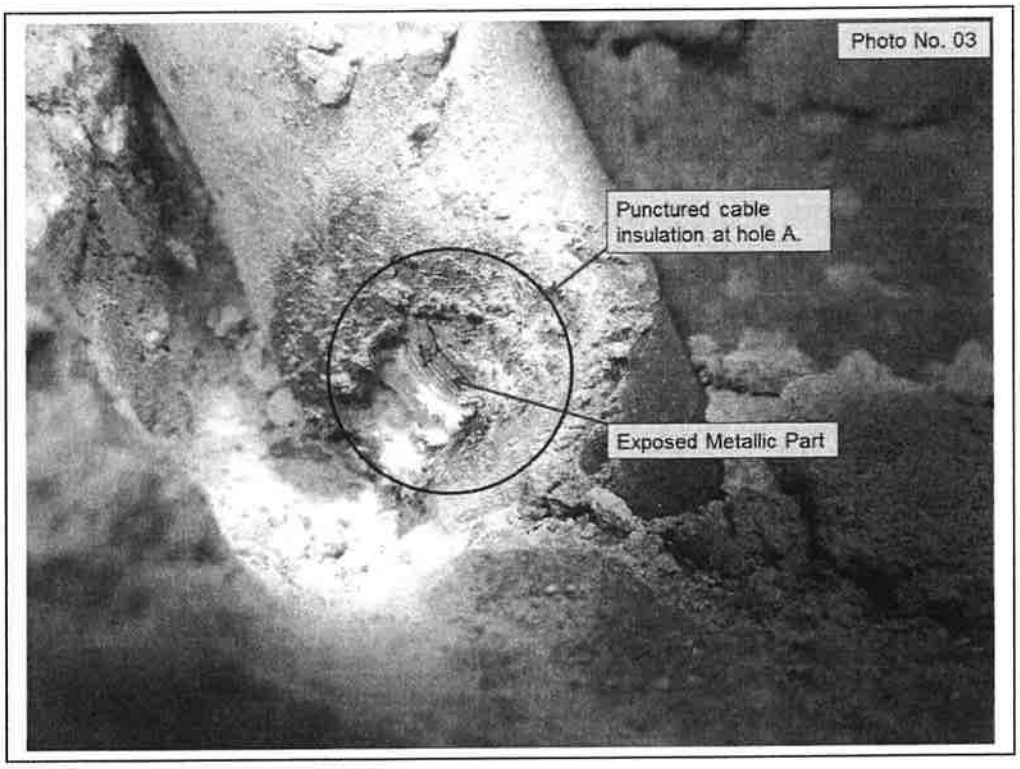


Photo No. 03
Punctured cable insulation at hole A
Exposed Metallic Part

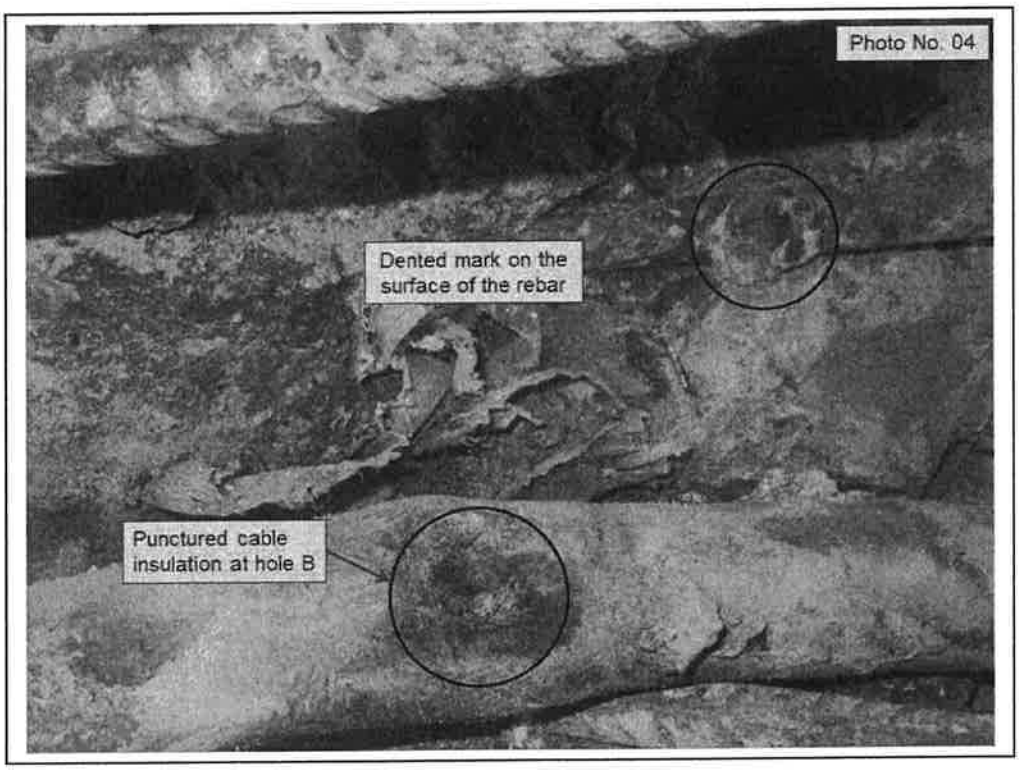


Photo No. 04
Dented mark on the surface of the rebar
Punctured cable insulation at hole B

Insulation resistance and continuity test was conducted on the metallic pneumatic breaker and the results showed that the pneumatic breaker was conductive. Tests conducted on hand groves and safety shoe shows that it does not have adequate insulation resistance to break the flow of current.

1.3 Conclusion

The victim's hands were gripping the metallic handles of the pneumatic breaker and his hand groves & safety shoes were wet during the course of work.

It.was possible that when the victim was using the pneumatic breaker for breaking the cement debris where the 'live' neoprene insulated cable was buried, the metallic chisel of the pneumatic breaker damaged the cable insulation and came into contact with one of the 'live' conductors of the neoprene cable. This would cause a current to flow from the exposed live cable cores through the metallic pneumatic breaker and the victim's body resulting in electrocution.

The current had caused the tripping of the 100A MCCB at DB-01 and the 250A MCCB at the upstream Sub-Board (SB-01), and the activation of the earth fault relay (set at 25A at 0.3 sec) at MSB No. 1 caused the tripping of the 250A MCCB.

1.4 What should be done to avoid danger ?

The accident could have been prevented if the 'live' cable and the control panel for the sump pump were decommissioned and removed before the commencement of construction work. Also, prior to the commencement of work, the cable should be checked using a voltage detector to confirm that it was not 'live' to ensure safety.

Case Study 2

2.1 Background

A worker was tasked to cut and remove the copper piping of an air-conditioning system above the false ceiling space of a vacant unit in a multi-tenanted commercial premises. He was informed that the electricity supply to the unit had been switched off.

The worker received an electric shock while cutting a 'live' electrical cable which he mistaken as an insulated air-conditioning pipe.

2.2 Investigation and findings

The tenant has vacated the premises and a contractor was appointed to carry out the dismantling and reinstatement work.

The victim and his co-worker were tasked to cut and remove the copper pipes of the air-conditioning system. At the time of the incident, the victim was standing on a metallic ladder to gain access to the false ceiling. He used a metallic cutter with a rubber insulated handle to cut away the copper pipes in the false ceiling while his co-worker was pulling out the copper pipes from a distance away. Moments later, the co-worker saw the victim lying motionless on the floor.

The cutter used by the victim was found with the metallic blades resting on a PVC insulated electrical cable. There was a few polyethylene insulated copper pipes and a green-yellow earth cable that had been cut in the vicinity of the cutter within the false ceiling. Voltage measurement between the metallic handle of the cutter in its original position and Earth was about 238V (see Photo No. 01 & Photo No. 02).

2.3 Conclusion

As the ceiling area was dark, the victim might have mistaken the 'live' sub-main cable as an insulated air-conditioning pipe that need to be removed.

The victim could have received an electric shock when the metallic cutter he was holding came into contact with the 'live' cable conductor at 238V (with respect to Earth), while part of his body was in contact with the earthed metallic pipes and other earthed metallic objects.

2.4 What should be done to avoid danger ?

The accident could have been prevented if the victim or his supervisor had used a voltage detector to verify that all the cables and metallic objects in

the false ceiling were "dead" before proceeding to cut the air-conditioning pipes. Workers shall be advised that they should treat any cable 'live' unless they had checked and confirmed that the cable is <u>not</u> 'live' before commencement of work.

