ESCOM
ELECTRICAL SAFETY COMMITTEE

# GUIDELINES AND BEST PRACTICES FOR CONSTRUCTION POWER

## PART 1: TEMPORARY CONSTRUCTION POWER

DOCUMENT NO – ESCOM/2024/04, Revision 1.0

## What is ESCOM?

The Safety, Health and Environment National Authority (SHENA) and Autoriti Elektrik Negara Brunei Darussalam (AENBD) established the Electrical Safety Committee or "ESCOM" in January 2023; with the objectives of promoting regulatory compliance and raising electrical safety standards within Brunei Darussalam.

## Who are the ESCOM members?

Members of the ESCOM comprised of industry experts from both government institutions and private organisations with decades of collective experience and a shared passion to drive improvements and promote electrical safety in Brunei Darussalam. The committee is co-chaired by both SHENA and Autoriti Elektrik Negara Brunei Darussalam (AENBD).

| **ELECTRICAL SAFETY BEST PRACTICES** | | | |
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Disclaimer:

*This document was developed as a recommendation and as an industry reference of best practices to improve electrical safety practices.*

*This document should not be construed as implying any liability nor should it be taken to encapsulate all the responsibilities and obligations of the law.*

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# 1 INTRODUCTION

## 1.1 Background

Numerous fatalities and electrical incidents resulting from electrocution that occurred in the last decade demonstrated shortcomings with regard to employee and personal safety in Construction Sites resulting from contact with live electrical installation (direct /or indirect). The common causes are:

1.1.1 unsafe situation, unsafe equipment, and unsafe system of work or work practices;

1.1.2 inadequate isolation and information;

1.1.3 poor control of work activities;

1.1.4 improper use of electrical appliances, extension cords, 2 and 3-pin plugs and socket outlets; and

1.1.5 lack of knowledge, person not trained / competent and many others.

## 1.2 Validity

This document is valid for five (5) years from the last revision date. Within this period, this document shall be assessed for relevance and re-validated in accordance with the review cycle and review process. Any suggestions for further improvement to this document can be sent to the Document Owner.

## 1.3 Introduction

This document and associated parts, EIR (Electrical Installation Requirement, DES), Safe Use of Electricity at Construction Sites and SHENA Industry Guidance Note provide the basic foundation on the requirement for any electrical installations and use of electrical tools serve as guidance reference /or minimum safety.

## 1.4 Purpose

1.4.1 The purpose of this document is to provide guidance on the minimum electrical standard when setting up mobile equipment {and/or} temporary power to be used in the period of construction or demolition work which is intended to be taken out of service upon completion of the works on mobile /or portable electrical tools /or equipment.

1.4.2 Compliance with relevant safety standards and requirements will enable the task to be properly carried out so as to avoid poor quality and damage to equipment, and facility and endanger people from suffering from electric shock & burns when they use unsafe equipment and in contacting overhead power lines & buried cables.

1.4.3 The requirements apply to fixed or moveable installations. This document deals with selection and application in the installation throughout the construction duration until it is removed. This document is not intended for the design, manufacturing, assemblies and testing of electrical equipment nor to instruct untrained persons.

## 1.5 Scope

1.5.1 The scope of this Guidance and Best Practices document covers on-site installations for one single source of power on local generation, distribution of electricity where electricity is used to facilitate various activities during the building or infrastructure development process, for electric operate tools, equipment, lighting, and other electrical devices as follows:

1.5.1.1 Part 1:- Temporary Construction Power

1.5.1.1.1 Circuit from ACS, i.e., site distribution board to sub-distribution board

1.5.1.1.2 From sub-distribution board to extension box

1.5.1.1.3 From sub-distribution board to tools/equipment

1.5.1.2 Part 2:- Standalone Portable /Mobile Generator > 10kVA to 1250 kVA

1.5.1.2.1 From local diesel genset to site distribution board.

1.5.1.2.2 LV single & 3 phases non-paralleling generator set from 10kVA to 1250kVA

1.5.2 The following are NOT included in this scope:

1.5.2.1 Setup and installation of HV equipment i.e., RMU (Ring Main Unit)

1.5.2.2 HV switchboard /switchgear both indoor and outdoor

1.5.2.3 Installation of Main feeder pillar, service pillar, distribution feeder panel of greater

1.5.2.4 Synchronizing of the generator to the grid

1.5.2.5 Paralleling of electrical distribution

1.5.2.6 Modification of existing system either extension or alteration of any installation

1.5.2.7 Equipment with self-contained battery supplies

1.5.3 This document is one of three guidelines and best practices documents, under the general title Guideline to Construction Power:

1.5.3.1 Part 1: Temporary Construction Power

1.5.3.2 Part 2: Standalone Portable /Mobile Generator >10 kVA to 1250 kVA

1.5.3.3 Part 3: Electrical Safety at Construction Site

1.5.4 Words that are in italic font *shall* be made reference to respective definitions.

## 2 DEFINITIONS

2.1 "Shall" - indicates a requirement strictly to be followed in order to conform to the standard and from which no deviation is permitted unless accepted by all involved parties.

2.2 "Should" - make a recommendation to indicate that among several possibilities one is recommended as particularly suitable without mentoring or excluding others, or that a certain course of action is preferred but not necessarily required.

2.3 "Can" - used for statements of possibility and capability, whether, physical or causal

2.4 "Could" - used to indicate an allowable course of action within the limits in this standard

2.5 "Conductor" - of material aluminum or copper metal forming a wire, cable or other designed for carrying electric current.

2.6 "Dead" - electrically discharged by being disconnected from any electrical supply and not having any charge retained by capacitance.

2.7 "Earth electrode" - A conductor or group of conductors in intimate contact with, and providing an electrical connection to, earth.

2.8 "Earth Resistance" - The resistance of the earth between the earth electrode and remote reference earth.

2.9 "Mean ground level" - average ground level

2.10 "Low voltage" - voltage that does not exceed 1000V AC or 1500Vdc

2.11 "Live (1)" - electrically charged by connected to low/high voltage electricity supply or having charge retained by capacitance.

2.12 "Live (2)" - in all circumstances, all electrical equipment is considered electrically charged until it is demonstrated, isolated, proved to be dead and earthed.

2.13 "High voltage" - voltages exceed low voltage U>1000V

2.14 "Insulation" - means separated from adjoining conducting material by a non-conducting substance which provides resistance to the passage of current, or to disruptive discharges through or over the surface of the substance at the operating voltage, and to mitigate the danger of shock or injurious leakage of current.

2.15 "Sag" - the distance measured vertically from a conductor to the straight line joining its two points of support. Unless otherwise stated in the rule, the sag referred to is the sag at the midpoint of the span.

2.16 "Clearance" - the clear distance between two objects measured surface to surface, and usually filled with a gas such as air.

2.17 "Span" - the horizontal distance between two adjacent supporting points of a conductor.

2.18 "Wayleave" - cleared swath of land / area under power overhead line

2.19 In addition to the following may or can be taken as the same meanings

2.19.1 Right-of-Way: - also known as Wayleave

2.19.2 Temporally equipment neither fixed nor stationary equipment.

2.19.3 Termination: - make connection.

2.19.4 Tie-in(s): - make connection.

2.19.5 Transportable / moveable: - as per "mobile"

2.20 Extracted from IEC 60050-212

2.20.1 Clause 212-11-18 "DC (electrification current)" – current after electrification by constant voltage between two electrodes in contact with an insulating material

2.21 Extracted from IEC 60050-141

2.21.1 Clause 141-02-06 "star connection" – in a polyphase element, connection in which all phase elements have a common node.

2.22 Extracted from IEC 60050-151

2.22.1 Clause 151-11-25 "equipment" - single apparatus or set of devices or apparatuses, or the set of main devices of an installation, or all devices necessary to perform a specific task

2.22.2 Clause 151-12-01 "electric circuit" - arrangement of devices, media, or both, forming one or more conductive paths and where these devices and media can have capacitive and inductive coupling.

2.22.3 Clause 151-12-07 "connection (1)" - intentional electric contact between conductors or intentional junction between waveguides including optical fibres.

2.22.4 Clause 151-12-08 "connection (2)" - conductor or electric circuit for joining terminals or other conductors.

2.22.5 Clause 151-12-09 "connecting" – the action of establishing a connection.

2.22.6 Clause 151-15-41 "insulation" – all the materials and parts used to insulate conductive elements of a device

2.22.7 Clause 151-16-44 "fixed" - fastened to a support or otherwise secured in a specified location.

2.22.8 Clause 151-16-46 "mobile" - capable of operating while being moved.

2.23 Extracted from IEC 60050-601

2.23.1 Clause 601-01-10 "distribution of electricity" – the transfer of electricity to consumers within an area of consumption.

2.23.2 Clause 601-03-04 "overhead line" – An electric line whose conductors are supported above ground, generally by means of insulators and appropriate supports.

2.24 Extracted from IEC 60050-826

2.24.1 Clause 826-16-04 "mobile equipment" - electrical equipment which can move or can be moved while in operation or which can be moved from one place to another while connected to the supply.

2.24.2 Clause 826-16-06 "stationary equipment" - fixed equipment or equipment that cannot be easily moved.

2.24.3 Clause 826-16-07 "fixed equipment" - electric equipment fastened to a support or otherwise secured in a specific location.

2.25 Extracted from IEC 61439-1

2.25.1 Clause 3.1.2 "assembly system" – a full range of mechanical and electrical components (enclosures, busbars, functional units, auxiliary circuits and associated controls, etc.), as defined by the original manufacturer, which can be assembled in accordance with the original manufacturer's instructions in order to produce various assemblies.

2.25.2 Clause 3.1.8 "functional unit" – part of an Assembly comprising all the electrical and mechanical elements that contribute to the fulfilment of the same function.

2.25.3 Clause 3.1.9 "incoming unit" – function through which energy is normally fed into the assembly.

2.25.4 Clause 3.3.2 "dead front assembly" – open-type assembly with front cover, the live parts possibly being accessible from directions other than the front.

2.25.5 Clause 3.3.3 "enclosed assembly" – assembly which is enclosed on all sides with the possible exception of its mounting surface in such a manner as to provide a defined degree of protection.

2.25.6 Clause 3.7.24 "class 1 assembly" – assembly with at least one provision for basic protection and a connection to a protective conductor as a provision for fault protection.

2.25.7 Clause 3.7.25 "class II assembly" – assembly which is provided with the following;.

2.25.7.1 Basic insulation as provision for basic protection and Supplementary insulation as provision for fault protection, or in which;

2.25.7.2 Basic protection and fault protection are reinforced insulation.

2.25.8 Clause 3.7.7 "fault current" - current resulting from an insulation failure, the bridging of insulation or incorrect connection in an electrical circuit.

2.25.9 Clause 3.8.6 "short-circuit current Ic " - overcurrent resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit

2.25.10 Clause 3.8.9.1 "rated voltage Un" - highest nominal voltage of the electrical system, declared by the assembly manufacturer, to which the main circuit(s) of the assembly is (are) designed to be connected

2.25.11 Clause 3.8.10.1 "rated current" – the value of uninterrupted current, declared by the assembly manufacturer which can be carried without the

temperature rise of various parts of the assembly exceeding specified limits under specified conditions

2.25.12 Clause 3.8.10.7 "rated current of an assembly InA" rated current which can be distributed by an assembly without the temperature-rise of any of the parts exceeding specified limits.

## 3 ACRONYMS AND ABBREVIATIONS

For the purpose of this document, the following abbreviation applies:

| | |
|---|---|
| AC | alternating current |
| DC | direct current |
| OHL | overhead line |
| HV | high voltage |
| LV | low voltage |
| RLV | reduce Low Voltage |
| PE | protective earth |

## 4 APPLICABLE STANDARDS AND INDUSTRY GUIDANCE

4.1 This standard cannot be used alone to specify an assembly or used for the purpose of determining conformity NEITHER apply to individual devices and self-contained components, such as circuit breakers, fuse switches, electronic equipment, etc., Assemblies *shall* comply with associated IEC & British standard but not limited to following:

4.1.1 The Electricity Safety, Quality and Continuity Regulations UK Statutory Instruments.

4.1.2 BS4363, Specification for distribution assemblies for reduced low voltage electricity supplies for construction and building sites.

4.1.3 BS7375, Distribution of electricity on construction and demolition sites - Code of Practice.

4.1.4 IEC 60245-4, Rubber insulated cables – Rated voltages up to and including 450/750 V –Part 4: Cords and flexible cables.

4.1.5 IEC 60309-1, Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements.

4.1.6 IEC 60309-2, Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories.

4.1.7 IEC 60364 (all parts), Low voltage electrical installations.

4.1.8 IEC 60364-4-41, Low-voltage electrical installations - Part 4-41: Protection for safety – Protection against electric shock.

4.1.9 IEC 60364-5-52, Electrical installations of buildings - Part 5-52: Wiring system equipment.

4.1.10 IEC 60364-5-53, Electrical installations of buildings - Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control.

4.1.11 IEC 60364-7-704, Low voltage electrical installations - Part 7-704: Requirements for special installations or locations - Construction and demolition site installations.

4.1.12 IEC 60364-7-717, Low voltage electrical installations - Part 7-717: Requirements for special installations or locations - Mobile or Transportable units.

4.1.13 IEC 61439-1, Low voltage switchgear and control gear assemblies - Part1: General Rule.

4.1.14 IEC 61439-3, Low voltage switchgear and control gear assemblies - Part3: Distribution boards intended to be operated by an ordinary person (DBO).

4.1.15 IEC 61439-4, Low voltage switchgear and control gear assemblies - Part4: Particular requirements for assemblies for construction sites (ACS).

4.1.16 EIR "Electrical Installation Requirements" published by Department of Electrical Services, Prime Minister's Office Brunei Darussalam.

4.1.17 ESCOM document No. ESCOM/2024/01, Title:- Guidelines and Best Practices for Public Lighting.

4.1.18 ESCOM document No. ESCOM/2024/02, Title:- Guidelines and Best Practices for Portable Appliance Testing.

# 5 TECHNICAL REQUIREMENT FOR TEMPORARY POWER

Temporary power refers to non-permanent power connected from the grid (i.e., DES /or BPS) it may also receive power from a portable generator. It is intended for a particular purpose and will be removed when it is no longer required for that purpose.

This guidance gives advice on precautions that can be taken to reduce the potential risk of accidents during the construction and demolition phase.

## 5.1 General Requirement

5.1.1 When temporary *Low Voltage* is needed at site, the following *shall* be submitted to the authorities (i.e., DES /or BPC) to obtain approval before any connection is to be made:

5.1.1.1 An estimated list / tabulated with electrical loads showing rated power and total consumption.

5.1.1.2 Single line diagram and equipment layout *shall* be for the temporary power system.

5.1.2 Before commencing any excavation, the construction team / contractor shall ensure the construction site is safe and clear from existing utilities i.e., underground cable, underground gas & water pipelines, and others by using the methods stated below: -

5.1.2.1 Scanning using cable avoidance tools (C.A.T) on all the perimeter of the construction site; or

5.1.2.2 Hand excavation: by manually performing pilot trenching using small tools like shovels, on all the perimeter of the construction site to a depth of 2m. The use of an excavator can only be accepted after conducting scanning / manual pilot trench has been completed.

5.1.2.3 Open trenches that are more than 2-3 days, shoring shall be provided with a strut throughout the whole length.

5.1.3 No electrical work to be carried out on live equipment.

5.1.4 Electrical equipment is considered only dead when it is isolated and connected to the earth.

5.2 Electrical Requirement

5.2.1 Electrical *equipment shall* be fully rated to nominal supply voltage in Brunei Darussalam, i.e., 3phases + N 400Vac or 1phase 230Vac +/-10%, 50Hz, this is aligned with BS7671 (IET wiring regulation) and harmonized with IEC standards.

**Table 5-1: Distribution Voltages for Typical Applications**

| Application | Voltage (V) | Systems |
|---|---|---|
| Fixed plant / equipment | 400 | Three-Phase |
| Movable Plant fed via a trailing cable over 3.75k | 400 | Three-Phase, or Single-Phase |
| Installation in site building | 230 | Single-Phase |
| Fixed flood lighting | 230 | Single-Phase |

| | | |
|---|---|---|
| Temporary Site Lighting, Portable electric hand-held tools used in confine space, i.e., Tunnel, Shaft, cofferdam, Tank, Boiler, Caisson, and others similar situation | 110 | Single-Phase Centre point earthed (RLV) |
| Portable hand-held lamps (confined space and damp situation) | 25 - 50 | SELV |

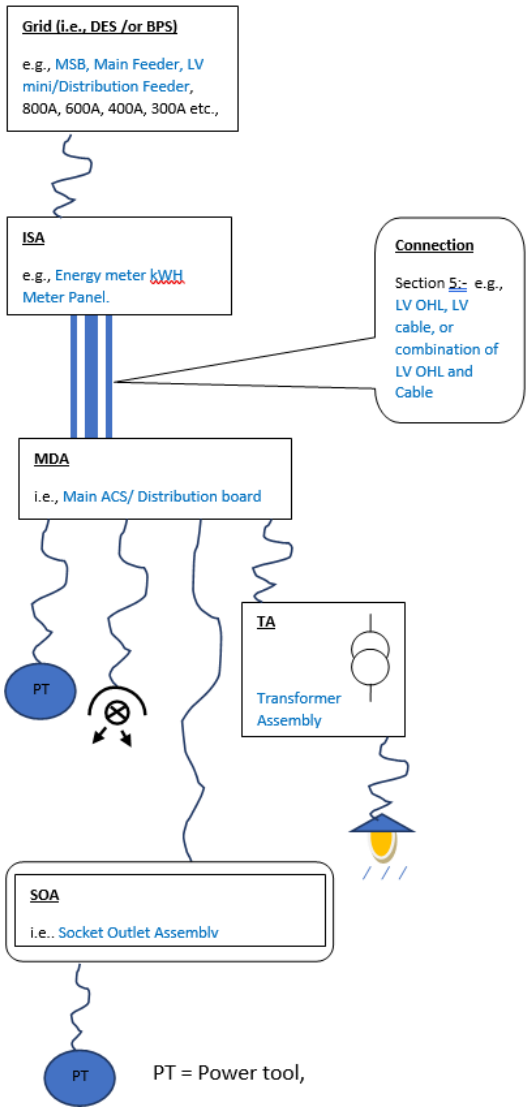



**Figure 5-1 Typical Block Diagram of Voltage Selection**

5.2.2 Voltage selection

5.2.2.1 The Figure 5-1 as shown provides guidelines on voltage use /selection summarized from BS 7375 Table 1.

5.2.3 Electrical installations *shall* be designed with adequate protection function which is automated to isolate and tripped to prevent abnormal conditions and faults that *can* endanger personnel and facility against:

5.2.3.1 Direct contact,

5.2.3.2 In-direct contact,

5.2.3.3 Thermal effects,

5.2.3.4 Overcurrent,

5.2.3.5 Fault current (all cases of short circuit and leakage),

5.2.3.6 Protected and shielded from the harmful environment (i.e., rain, hydrocarbon gases etc.,).

5.2.4 Metallic enclosure associated with any electrical equipment in a network that receives LV ac or dc *shall* be connected to the earth. References made to Part-II clause 10-(1), The Electricity Safety, Quality and Continuity Regulation 2002 UK (ESQRC United Kingdom).

5.2.5 Electrical wire/cable for each final lighting *shall*

5.2.5.1 be connected by Not less than 1.5mm2 copper *conductors* wire, rated to 450/750 VAC.

5.2.5.2 be PVC /or Rubber insulation,

5.2.5.3 be colour-coded according to the latest edition IET Wiring Regulation Table 51 BS7671:2018 as per Table 5-2 below:

**Table 5-2: Identification of Conductors**

| Function | Alphanumeric | Colour |
|---|---|---|
| Protective conductor (both 1 phase and 3 phases) | PE | Green-and-yellow (GNYE) |
| 1 phase AC power circuit | | |
| Line | L | Brown (BN) |
| Neutral | N | Blue (BU) |
| 3 phase AC power circuit | | |
| Line 1 | L1 | Brown (BN) |
| Line 2 | L2 | Black (BK) |
| Line 3 | L3 | Grey (GY) |

5.3 Making connections and tie-in to existing LV utility grid.

5.3.1 Various methods of *connection can* be made as stated below:

5.3.1.1 Via LV OHL, (Low Voltage Overhead line)

5.3.1.2 Via Power Cable

5.3.1.3 Combination of OHL and power cable

5.3.2 Connection via OHL

5.3.2.1 Where works are to be conducted below or adjacent to existing OHL, it is the duty of the construction team to engage the utility overhead electric line owner (DES/BPC) in regard to safe working distance and safety requirements before commencing any activity. This is not limited to setting up temporary structures (such as scaffolding), temporary offices, sky-cradle / crane / Hiab operation, tree & branch trimming, painting and refurbishment of any existing infrastructural works, and many other activities near an overhead line.

5.3.2.2 All *low voltage* (L.V.) overhead lines mounted on pole(s) shall adhere to DES requirements. L.V. overhead line *CONDUCTOR shall* be fully insulated such as ABC (aerial bundled insulated cable) to prevent electrical shock from direct contact, and the use of bare overhead line is prohibited.

5.3.2.3 Overhead L.V conductor rating shall not be less than the total loads' currents as per the submitted load list, and ABC cable with the aluminium conductor, round stranded compressed, XLPE compound and fully rated to 0.6/1kV with UV-resistance.

5.3.2.4 Overhead line conductors shall be fitted and secured with an insulator(s) as per UK Electricity Safety, Quality and Continuity Regulation 2002 Part V clause 18-(1) which states: *"Any part of an overhead line which is not connected with the earth, and which is not ordinarily accessible shall be supported on insulators or surrounded by insulation."*

5.3.2.5 Minimum approach distance (MAD) and clearance distance: -

5.3.2.5.1 Where a temporary LV OHL is erected for any construction activity and is not over a public road, the minimum approach distance and clearance distance *shall* be maintained from the overhead line on both sides along the complete length of the installation.

5.3.2.5.2 Recommended minimum approach distance and clearance distance as per ESQCR and ENA UK standards are summarized in Table 5-3 & Table 5-4 as seen below and *shall* always be adhered to.

**Table 5-3 Safe distances from conductors to ground**

| Circuit voltage Not exceeding 33kV | clearance to ground (m) |
|---|---|
| Bare live metal | 4.3 |
| line conductor not over road | 5.2 |
| line conductor to road surface | 5.8 – 14 * |
| | *for 3 lane motorways. |

**Table 5-4 Safe distances from conductors to objects**

| Circuit voltage Not exceeding 33kV | clearance to objects (m) |
|---|---|
| Bare live metal (e.g., fence, ladders, trees etc.,) | 3.0 |
| Along the line of hedgerows, fences boundaries and walls etc. | 4.0 |
| Along domestic roads / driveways | 4.3 |
| line conductor to street lighting | 1.7 |

5.3.2.5.3 LV Overhead line shall comply with a minimum (height) clearance of 4.3m at maximum temperature measured from the lowest point to the mean ground level and barricaded with 1.8m insulated chain link fence throughout the perimeter / whole length of OHL on both sides as per Figure 1 and 2. Where minimum distance is not met, in addition to perimeter fences, the construction shall use add-on visibility to minimize the danger by using other methods including bunting, height-restricting goalposts, warning signs and lighting.

5.3.2.5.4 Where a vehicle crossing OHL is foreseen, 5.8m shall be maintained at the lowest point of the line conductor to the road surface. This requirement is extracted from Part-V clause 17-(4) The Electricity Safety, Quality and Continuity Regulation 2002 UK (United Kingdom),

5.3.2.5.5 “The height above ground of any wire or cable which is attached to a support carrying any overhead line shall not be less than 5.8 metres

at any point where it is over a road accessible to vehicular traffic".

5.3.2.5.6 It should be noted that the same clearance of 4.0m shall be kept when temporary OHL from trees and branches and hence the contractor shall obtain approval from authorities on the proposed wayleave of temporary LV OHL.

5.3.2.5.7 No temporary structures (such as scaffolding, ladders), mobile facilities, machinery, such as cranes, dump trucks and equipment are to be kept near temporary overhead lines without any written consensus from authorities (i.e., DES /or BPC).

5.3.2.5.8 It should be noted that the MAD is a guide where it could be changed due to other factors which may arise. Such factors could be environmental conditions such as hot / rainy days, windy conditions, conditions of worker clothing & footwear, type of *conductors* and their operating voltage etc.

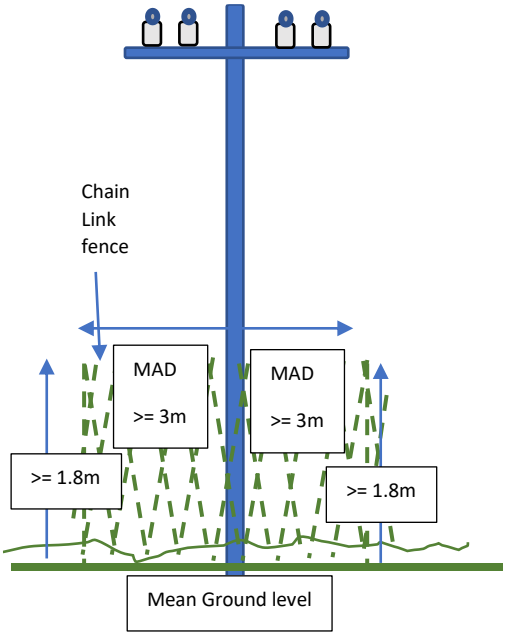



**Figure 5-2 Sketch of the side view of MAD and Clearance**

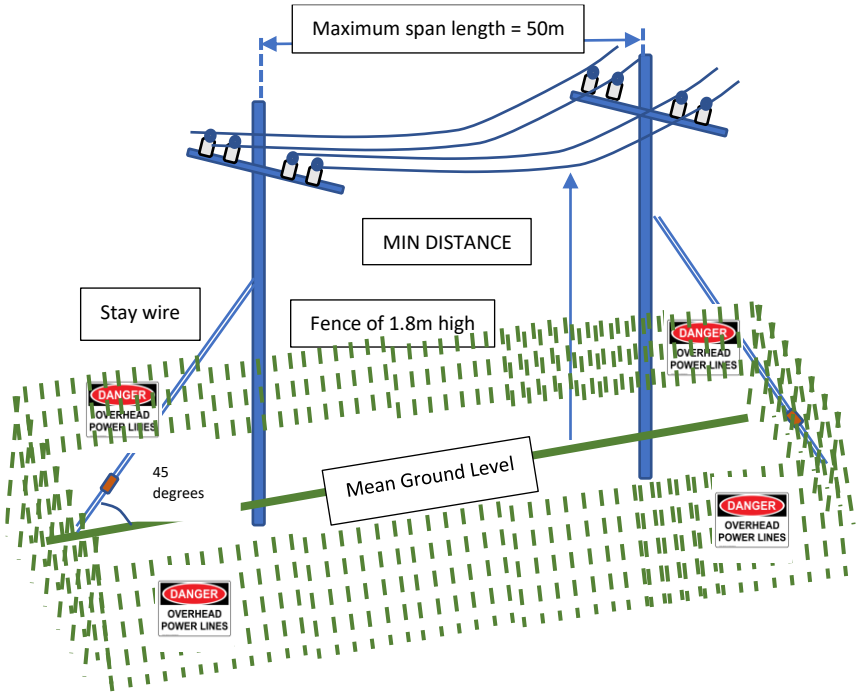



**Figure 5-3 Sketch of the front view on MAD and Clearance Distance**

5.3.2.5.9 stay wire(s) shall be fitted at each end of OHL poles and where there is a change in direction. An insulator shall be fitted on each bare stray wire no less than 3m above ground arranged with a minimum angle of 45degree measured from the ground to stay wire, see Figure 2 above. References of 3 meters above ground are dictated as per Part-V, Clause 20 Fitting of insulators to stay wires, The ESQCR (Electricity Safety, Quality and Continuity Regulation) 2002 UK (United Kingdom),

5.3.2.5.10 The contractor shall consult with DES/BPC on the minimum length/height of the LV overhead line pole.

5.3.2.5.11 Poles of LV overhead line shall be of either: -

5.3.2.5.11.1 Buried: Buried poles shall have a minimum depth of 2m concreted at the base and top of the soil. The base concrete shall comply with the DES drawing title: Typical Pile Foundation Detail For Concrete Electric Poles JPE/CP/PFN.

5.3.2.5.11.2 **Bolted:** Where pole with base/flange for bolted type, J-bolted shall be attached to the steel reinforcement and concreted in one piece. Used of expansion bolts is prohibited.


5.3.2.5.12 Danger signage shall be provided at both sides of the overhead line with a security gate, guarded by security personnel for heavy /high vehicle entry.

5.3.2.5.13 It is prohibited to mount or attach foreign objects (such as advertisement billboards), or other service lines (e.g., telephone, FO etc.,) on any temporary OHL pole.

5.3.2.5.14 All metallic poles shall be welded with an M10 earthing stud for earthing connection and provided with anti-climbing from unauthorized access.

5.3.2.5.15 Installation of LV temporary OHL along /below, crossing existing OHL is not supported.

5.3.3 Connection via Underground Cable

5.3.3.1 An electric power cable is the most common means of making a connection. However, the following *shall* be complied with: -

5.3.3.1.1 Power cable *shall* be of complete length without any joint and comply with clause14 (1), (2) & (3) Part-III, The ESQCR (Electricity Safety, Quality and Continuity Regulation) 2002 UK (United Kingdom) that,

5.3.3.1.1.1 power cable shall be laid in the ground to a depth of not less than 600mm,

5.3.3.1.1.2 where it is inevitable to be laid on a surface either vertically or horizontally, the cable tray & ladder shall be provided for the whole length

and protected by cable tray cover from damage or danger from the use of land.

5.3.3.1.1.3 buried underground power cable shall be: --

- protected by cable protection tiles without spacing in between or
- by metallic pipe, duct or equivalent i.e., steel reinforced concrete block of not less than 300x300x100mm (LxWxH)
- provided with warning tape, warning devices, marks or indication.

5.3.3.1.2 All *low voltage* (L.V.) power cables *shall* comply with Brunei authority requirements as follows:-

5.3.3.1.2.1 DES Technical specification No:- DES/11kV/LVC of title :- 600/1000V XLPE cable or

5.3.3.1.2.2 DES Technical specification No:- DES/PVCSWA/PVC/LVC of title:- PVC/SWA/PVC LV Cable

5.3.3.2 Use of flexible cable shall be of H07RN-F type with the following:-

5.3.3.2.1 fully rated to maximum load current (A)

5.3.3.2.2 withstand fault current to 1 sec (kA)

5.3.3.2.3 insulation shall be rated to 0.45/0.75 V

5.3.3.2.4 copper material

5.3.3.2.5 of multicore

5.3.3.2.5.1 5c (3 phase + Neural + Earth)

5.3.3.2.5.2 4c (3 phase + Neutral) where a separate earth wire shall be provided

5.3.3.2.5.3 3c (1 phase + Neutral + Earth) for single phase cable with earth wire

5.3.3.3 Minimum size or earth wire can be selected from IEC 61439-1 as per below:-

**Table 5-5 Minimum terminal capacity for copper protective conductors**

| Cross-sectional area of line conductors, S (mm2) | Minimum cross-sectional area of the corresponding protective conductor, Sp (mm2) |
|---|---|
| S <= 16 | S |
| 16 < S <= 35 | 16 |
| 35 < S <= 400 | S/2 |
| 400 < S <= 800 | 200 |
| 800 < S | S/4 |

5.3.4 Combination of OHL and power cable

Sections 5.3.2 and 5.3.3 applied.

# 6 ELECTRICAL EQUIPMENT AT THE SITE

## 6.1 Local diesel generator set

Refer to Part 2: Portable /Mobile Generator > 10kVA to 1250kVA.

## 6.2 Assemblies for Construction Site "ACS"

Also known as site Distribution Board (DB)

### 6.2.1 Information

The following information *shall* be provided as part of the nameplate of "ACS"

6.2.1.1 *InA*, rated current of assembly

6.2.1.2 *Un,* rated voltage of assembly

6.2.1.3 fn, rated frequency of the assembly

6.2.1.4 *Inc*, load current and diversity factors used

6.2.1.5 Types of earthing e.g., TT or TNS

6.2.1.6 Installation, indoor and /or outdoor

6.2.1.7 Stationary or movable

6.2.1.8 IP code

6.2.1.9 Weight kg

6.2.1.10 SLD and interfacing drawings

6.2.2 Electrical loading

6.2.2.1 A permanent tag or label with electrical current rating shall be placed on fuse carriers, fuse bases, and panel/door front cover on each functional unit (both Incoming and outgoing) to indicate the maximum load current under load conditions of continuously and simultaneously operation stated in terms of rated current Inc and the rated diversity factor.

6.2.2.2 As per IEC 61439-1 section 5.4:-

6.2.2.2.1 "The rated diversity factor is the per unit value of Inc, to which outgoing circuit can be continuously and simultaneously loaded in the same section of the assembly taking into account the mutual influences" and,

6.2.2.2.2 "The rated diversity factor multiplied by the rated current Inc of the circuits *shall* be equal to or higher than the assumed loading of the outgoing circuits, where the assumed load current is equal to the design current $I_B$ for continuously and simultaneously loaded circuits.

6.2.2.3 In this document, the InA (rated current of the Assembly) shall not be less than the total load currents, i.e., the total arithmetic sum of electrical load current from outgoing circuits:-

6.2.2.3.1 *InA*, is the rated current of the Assembly or rated current of the Incomer function or main Busbar whichever is smaller.

6.2.2.3.2 *Inc* is *rated* current of the outgoing circuit.

6.2.2.3.3 *In* the *absence* of the diversity factor stated by the manufacturer, the actual load current *can* be predicted by Assuming the load factor of IEC 61439-3, Table 101.

6.2.2.4 Electrical distribution board /or ACS used at the construction site shall have its electrical loading in accordance with IEC 614393-3 Table 101 as per Table 6-1 below:-

**Table 6-1 Value of assuming loading (Table 101)**

| Number of outgoing circuits | Assuming Loading factor |
|---|---|
| 2 and 3 | 0.8 |
| 4 and 5 | 0.7 |
| 6 to 9 | 0.6 |
| > = 10 (More than and equal to) | 0.5 |

6.3 Internal separation

6.3.1 IEC 61439-1 section 8.2.2 indicated degree of protection against contact with live parts *shall* be at least IP2X (solid object of >=12.5mm diameter), and IPX3B against contact with hazardous part / against access of finger.

6.3.2 In addition ACS shall have Form 3b segregation (i.e., terminals for external conductors and external conductors separated from busbars) where insulated busbars within the air-insulated compartment and live as per Figure 6-1 seen below.

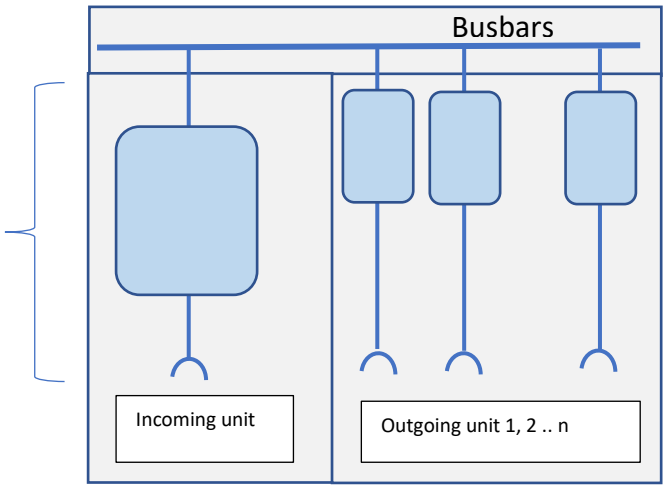



**Figure 6-1 Internal Separation**

6.4 Functional requirements

6.4.1 ACS shall comply with EIR "Electrical Installation Requirements" published by the Department of Electrical Services, Prime Minister's Office Brunei Darussalam.

6.4.2 IEC 61439-4- Section 8.5.3 stated that:-

6.4.2.1 Single-phase (1-phase) plugs and socket outlets of different rated currents or voltages *shall* not be interchangeable.

6.4.2.2 Three-phase (3-phase) plugs and socket outlets *shall* be arranged to retain the same order of phases and rotation.

6.4.3 IEC 61439-1 section 8.2.2 indicated a degree of protection against contact with live parts *shall* be at least IP2X (solid object of >=12.5mm diameter), and IPX3B against contact with hazardous part / against.

6.4.4 In accordance with IEC 60346-1 part 7-704, part 7-740 except for emergency lighting, all final circuits for lighting, socket-outlets of rated current up to and including 32A and other circuits supplying portable equipment, hand-held electrical equipment connected by flexible cable or cord *shall*:

6.4.4.1 be protected by automatic disconnection of supply together with Additional protection by a residual current device not exceeding 30mA else .

6.4.4.2 be supplied by SELV or PELV (see IEC 60364-4-41 clause 414).

6.4.4.3 has electrical separation of circuits (see IEC 60364-4-41, clause 413), each socket-outlet and hand-held electrical equipment being supplied by an individual isolating transformer or by separate windings of an isolating transformer.

6.4.4.4 double or reinforced insulation.

6.4.4.5 RCBO shall be of 2-poles for single-phase (1-phase) 230Vac circuits and 4-poles for three (3-phase) 400Vac circuits.

6.4.5 In addition to 6.4.4 above, the IET wiring regulation 704.410.3.10 states "A circuit supplying a socket-outlet with rated current up to and including 32A and any other circuit supplying hand-held electrical equipment with rated current up to and including 32A shall be protected by Reduce Low Voltage."

6.4.6 Incoming functional units of ACS *shall* be provided with protection devices for overcurrent & fault current and isolating devices capable of padlocking in the "OFF /or Open" position.

6.4.6.1 When an ACS incomer contains fuses as current limiting devices it shall meet the following requirement: Keyed door cover for access to fuse(s) replacement shall be interlocked with isolating devices/ actuator of the main switch after isolated / switch-off.

6.4.6.2 An engraved tag / label shall be placed on fuse carriers, fuse bases, and panel/door front cover of the incomer isolation device stating the type and rating of fuse link.

6.4.6.3 An interface barrier shall be provided to minimize danger when replacing fuse links.

6.4.7 Reduce Low Voltage

6.4.7.1 Commonly known as 110V center-tap earthing systems.

6.4.7.2 BS 7671 defined Reduce Low Volage (RLV) as "A system in which the nominal line-to-line voltage does not exceed 110V and the nominal line-to-earth voltage does not exceed 63.5V".

6.4.7.3 BS 7375 Distribution of electricity on construction and demolition site-code of practice recommended the use of RLV for builders, and contractors to feed socket outlets, portable equipment, and temporary lighting on construction sites.

6.4.7.4 RLV shall be arranged as per Appendix 2 and meet with the following requirement:

6.4.7.4.1 having low impedance path to enable the overcurrent device to operate in a short space of time enforcing all exposed metallic parts shall be connected main earthing bar in the ACS and earthing wire to the final circuit.

6.4.7.4.2 a proving unit /or protective conductor circuit shall be installed to ensure continuity of PEC, protective earth conductor connected between the origin of the installation and the apparatus to be protected with two (2) independent earth terminals on the casing. Refer to Appendix 1 for a typical protective conductor proving circuit.

6.4.7.4.3 to be equipped with both overcurrent/short circuit protection and 30mA RCD additional protection in all line conductors.

6.4.7.4.4 only double wound isolating transformer shall be used.

6.4.7.4.5 The use of the TNC-S system is deprecated.

6.4.7.4.6 electrical accessories/appliance, socket outlet etc., shall be dimensional different and not interchange with appliance use for 230V.

6.4.7.4.7 for 3 phase 110V RLV,

6.4.7.4.7.1 3 wires delta connection for primary winding and star connection for secondary winding.

6.4.7.4.7.2 3 wires delta connection for primary winding and star connection for secondary winding.

6.4.7.4.7.3 neutral (star) point of secondary windings shall be connected to the ACS earthing bar or connected to a local earthing pit of not more than 1-ohm earthing resistance.

6.4.7.4.7.4 3-poles MCB, L1, L2, & L3.

6.4.7.4.8 for Single phase 110V RLV,

6.4.7.4.8.1 center-tap (i.e., 1-phase 50V-0-50V) earthed to ACS earthing bar or connected to a local earthing pit of not more than 1-ohm earthing resistance.

6.4.7.4.8.2 3-wire L1, L2 +E (i.e., of colour brown for both live conductors, L1 and L2)

6.4.7.4.8.3 2-poles MCB shall be used for all outlets feeding from transformer outputs.

6.4.8 For positive isolation, all phase(s) *conductors* and neutral must be disconnected and switched off in the event of isolation and tripped automatically upon detection of fault current & overcurrent.

6.4.9 Where ACS may include voltages other than 230Vac or 400Vac (e.g., LV/LV transformer, LV/ELV transformer, rectification & DC voltages etc.,) they *shall* be segregated in separated compartments.

6.5 Construction and installation requirement

6.5.1 Where the "ACS" is used at the site and is not fixed in an enclosed room, it *shall* be capable of providing protection against dust and water jets. A minimum protection against contact with live parts, ingress of solid foreign bodies and water (IP code) *shall* be IP55 and provided with a rain canopy for any setup in an outdoor environment.

6.5.2 Design IP rating *shall* be maintained to the complete assembly and its connecting cables either fixed (terminated) or removable part after:-

6.5.2.1 Installation at site;

6.5.2.2 Where plug(s) is/are inserted / withdrawal; or

6.5.2.3 Cables are terminated, etc.

6.5.3 All connections for external cables *shall* be detachable via surface mounted Industrial socket outlet of IP55 and have a current rating of at least 16A.

6.5.4 Colour of Plugs, socket-outlets/receptacles and couplers as per IEC 60309-1 and BS 7375 as seen in Table 6-2 below:-

**Table 6-2 Colour codings of plugs, socket outlets and couplers**

| Operating voltage | Colour |
|---|---|
| 100 to 130 | Yellow |
| 200 to 250 | Blue |
| 380 to 480 | Red |

6.5.5 ACS shall be of *enclosed assembly* design for outdoor application, provided with a supporting structure that is suitable for free-standing equipped with carry handle and lifting provision.

6.6 Mobile / movable electrical tools and appliances

6.6.1 All electrical equipment /tools with an electrical cord connected to 230Vac supply shall comply with ESCOM document No. ESCOM/2024/02, Title:- Guidelines and Best Practices for Portable Appliance Testing.

6.6.2 Electrical equipment /tools with electrical cord connected to 230Vac supply use at site *shall* meet the following Type of Appliance:-

6.6.2.1 Class I or,

6.6.2.2 Class II

6.6.3 Class I

6.6.3.1 In addition to Clause 5.2 Electrical Requirements, the use of electrical equipment connected by an electrical cord to 230Vac supply *shall* be:

6.6.3.1.1 double insulated multicore cable inclusive earth wire of the same cross-section area (CSA),

6.6.3.1.2 metallic enclosure and its metallic structural frame *shall* be equally bonded and effectively earthed to one (1) ohm max /or,

6.6.3.1.3 be protected by RCD of fixed sensitivity of 30 mA for personal protection, and operating time not exceeding 40 ms at a residual of 5 x I Δn (nominal current)

6.6.3.1.3.1 For lighting installation mounted on metallic structural/poles/pillars etc.,

6.6.3.1.3.2 For any other electrical equipment connected to the distribution board, ACS etc.,

6.6.3.2 For multiple socket outlet distribution panels, an RCD of 30mA shall be provided to every loop of a circuit where an outdoor electrical appliance is connected to a socket outlet.

6.6.4 Class II

6.6.4.1 Where basic protection and fault protection are provided by double insulation or reinforced insulation, any outdoor electrical luminaire that is/are to be used in the construction site *shall* be:

6.6.4.1.1 Fully PAT (Portable Appliance Testing) tested not less than 500V in accordance with ESCOM Portable appliance testing consumer requirements.

6.6.4.1.2 Any non-permanent (i.e. portable, handheld, suspended type, etc.,) *shall* not be used if the PAT verification sticker is not adhered/provided, failed or "validity test due".

6.6.4.1.3 Non-permanent appliances that pass the PAT test, marked or attached with "Green" identification and signed by an authorized tester *shall* only be used in public. (i.e., like weight measuring units).

6.6.4.1.4 For multiple socket outlet distribution panels, an RCD of 30mA *shall* be provided to every loop of a circuit where an outdoor electrical appliance is connected to a socket outlet.

# 7 TYPE OF SYSTEM EARTHING AND EARTHING ARRANGEMENT

7.1 Permitted Type of System Earthing

7.1.1 A copper earthing bar *shall* be provided inside the enclosure /ACS to facilitate automatic disconnection of the supply for protection against earth faults either internal or external of the assemblies and that to which all metallic parts are electrically connected. Such metallic parts may not be limited to: -

7.1.1.1 Metallic enclosure of the ACS.

7.1.1.2 None welded / bolted structural support, of the ACS inclusive footing/legs.

7.1.1.3 None welded / bolted carrying handles.

7.1.1.4 Lids, doors or covers.

7.1.1.5 Earth terminals of all electrical accessories i.e., Socket-outlets, terminals.

7.1.1.6 Armoured and earthing conductors / wire /lead of power cables.

7.1.1.7 For connection to earthing arrangement /electrodes

7.1.2 Upon completion / setup of ACS at a construction site, the earth resistance shall not exceed one (1) ohm.

7.1.3 Where TT earthing system is applied, a dedicated earth electrode shall be provided to the Main ACS connecting from the electrical grid, feeder pillar/panel etc. in ring configuration with redundancy for safety protection.

7.1.4 Where intermediate ACS is used for connection between the final circuit and Main ACS, it *shall* be:-

7.1.4.1 Electrically connected to main ACS by yellow/green PVC insulated copper earthing *conductor* / wire with CSA selected as per table 5 above in ring configuration for redundancy or

7.1.4.2 Having a dedicated *earth electrode* with *earth resistance* not exceeding one (1) ohm.

7.1.5 The complete ACS installation shall comply with either TNS and/or TT system network configuration.

7.2 Earthing Arrangement

7.2.1 Regardless of the "Types of system earthing", the protective earth *conductor* /or wire shall not be switched off in any event of maintenance neither by any means of isolation nor tripping during fault or overcurrent and/or earth fault.

7.2.2 It is prohibited to apply PME /or TNC-S for any ACS. This requirement is dictated in Part-II, clause 8-(4) ESQCR (The Electricity Safety, Quality and Continuity Regulation) 2002 UK (United Kingdom):

"*A consumer shall not combine the neutral and protective functions in a single conductor in his consumer's installation".*

7.2.3 Any extraneous conductive parts such as metallic structure, or water pipe shall not be treated as earth electrodes.

# 8 EMERGENCY AND ESCAPE LIGHT

8.1 8.1Where escape and emergency light(s) is / are power up from ACS,

8.1.1 If normal power fails, the Contractor is responsible for ensuring that these lights are able to maintain minimum illumination and 60 minutes of backup time as per ESCOM document No. ESCOM/2024/01, Title:- Guidelines and Best Practices for Public Lighting.

8.1.2 When external alternative sources other than self-contained are used to sustain the illumination and 60-minute backup, the connecting cable should be of low smoke zero halogens with fire resistance properties in accordance with IEC 60331.

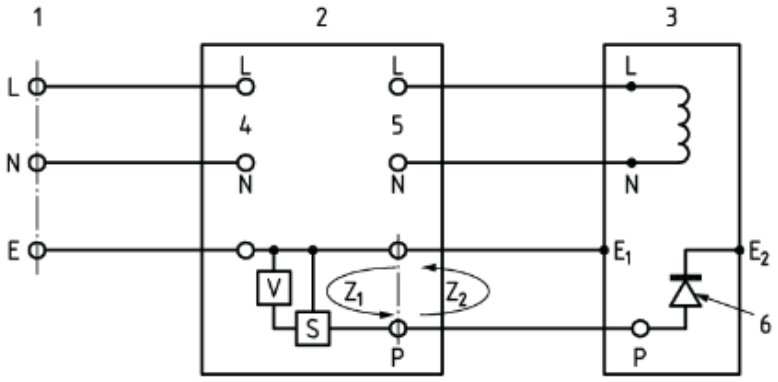
# 9 APPENDICES

Appendix 1:- Typical protective conductor proving circuit with test facility shown open (as per BS7375 Figure 2).

Appendix 2:- A typical distribution system extracted (as per BS7375 Annex A).

Appendix 3:- Case Study on temporary construction installation.

## 9.1 APPENDIX 1: TYPICAL PROTECTIVE CONDUCTOR PROVING CIRCUIT WITH TEST FACILITY SHOWN OPEN (EXTRACTED FROM BS7375 FIGURE 2.)

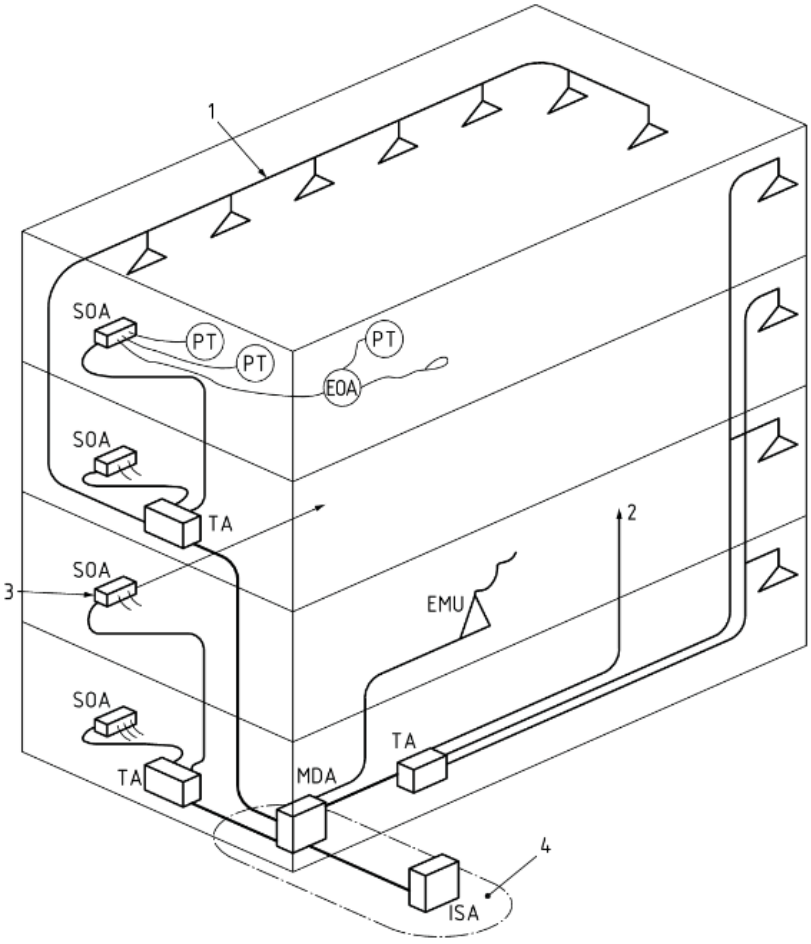



**Key**

1 Origin
2 Proving unit
3 Apparatus
4 Supply terminals
5 Load terminals
6 Diode (optional)
$E_1$ Protective earth terminal
$E_2$ Earth terminal for pilot circuit (this may be internal or external)
*P* Pilot conductor terminal
*S* Sensing device
*V* Extra-low voltage source
$Z_1$ Impedance of source
$Z_2$ Impedance of the loops

*NOTE If a diode is not used then a link has to be provided for a direct connection between terminals P and $E_2$.*

## 9.2 APPENDIX 2: A TYPICAL DISTRIBUTION SYSTEM (EXTRACTED FROM BS7375 ANNEX A)




**Key**

1 General floor lighting connected direct to transformer assembly TA

2 Access and security lighting

3 1.5 to 3.0 kVA heavy portable to suit site conditions; tools, if required, can be connected through a 3 optional socket-outlet assembly (SOA)

4 ISA and MDA may also be provided as one assembly (ISDA)

Lighting

PT Portable tool

Earth monitoring unit

*NOTE ISA and ISDA may also be provided as one assembly (ISDA) to suit site conditions.*

Annex A (informative)

# A typical distribution system using distribution units

Figure A.1 shows a typical site arrangement utilizing the distribution units specified in BS EN 60439-4 and BS 4363, and Figure A.2 shows in greater detail how these units can be used to provide supplies in a multi-storey building under construction.

Brief descriptions of six types of distribution unit are as follows.

a) *Incoming supply assembly (ISA).* This comprises an assembly of equipment for the control and distribution of electricity on a site arranged to accommodate the electricity distributor's equipment and to provide facilities for connecting one outgoing circuit.

b) *Incoming supply and distribution assembly (ISDA).* This comprises an assembly of equipment for the control and distribution of electricity on a site arranged to accommodate the electricity distributor's equipment and to provide facilities for connecting circuits at system voltages up to 400 V three-phase and 230 V single–phase a.c.

c) *Main distribution assembly (MDA).* This comprises an assembly of equipment for the control and distribution of electricity on a site at system voltages up to 400 V three-phase and 230 V single-phase a.c.

d) *Transformer assembly (TA)(TA/1 single-phase, TA/3 three-phase, TA/1/3 single- and three-phase).* This comprises an assembly of equipment incorporating a transformer and arranged to distribute electricity at reduced low voltage.

e) *Socket-outlet assembly (SOA)(SOA/1 single-phase, SOA/3 three-phase).* This comprises an assembly of equipment providing facilities for the control, protection and connection of final circuits at reduced low voltage, this assembly being fed from a 32 A supply.

f) *Extension outlet assembly (EOA)(EOA/1 single-phase, EOA/3 three-phase).* This comprises an assembly of equipment providing facilities for the connection of final circuits at reduced low voltage, this assembly being fed from a 16 A supply.

*NOTE In Figures A.1 and A.2, no differentiation is made between single-phase and three-phase units, and therefore the numerical part of the abbreviations is omitted.*

## 9.3 APPENDIX 3: CASE STUDY ON TEMPORARY CONSTRUCTION INSTALLATION

**Case study**

A worker at construction site experienced a fatal electric shock when he was asked to adjust the position of temporary portable lighting pole connected with trailing cable to a distribution board located 50 meters away. Subsequent investigation identified that there was an electricity leaking along the cable connecting to the lighting pole and a few connections of the trailing cable was partly placed on wet water.

**Safety messages**

- Improper setup of temporary lighting pole without leakage protection and poor earthing.
- Inspection and testing of the installation shall be conducted by competent person.
- Isolate power and do not work on live equipment.
- Recommended to consider the use of RLV for temporary portable equipment with proper earthing.