LIBERIA ELECTRICAL WIRING CODE

APRIL 2023

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Foreword

The Liberia Electrical Wiring Code (LEWC) is published to give general technical guidelines on how the statutory requirements of the Electrical Wiring Regulations can be met.

The structure of the LEWC corresponds to that of the Electrical Wiring Regulations in that a code will be associated with a corresponding regulation of the Wiring Regulations. Compliance with the LEWC should achieve compliance with the relevant aspects of the Electrical Wiring Regulations.

The LEWC is further linked to another set of statutory requirements issued as Certification and Licensing of Electrical Professionals and Contractors Regulations which elaborate the qualification criteria for electrical professionals and contractors for undertaking electrical wiring/installation work. Procedures for certification or licensing to undertake various classes and categories of electrical work are provided and monitoring framework established to facilitate regular inspections of quality of electrical wiring/installation works undertaken by practitioners.

It is expected that enforcement of this LEWC in conjunction with the other two statutory instruments will introduce some appreciable level of sanity into the Liberia electricity industry in ensuring safety and rapid growth of the industry.

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3. Copies of the complete standards listed above are available for sale from the respective organizations. The addresses of the organizations are:
    (a) **International Electrotechnical Commission**: IEC Central Office, 3 rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland
    (b) **British Standards Institution**: 389 Chiswick High Road, London, W4 4AL, United Kingdom
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PART A

CODE 1: INTRODUCTION

1.1 Scope and Objectives

1.1.1 Purpose

1.1.1.1 The Liberia Electrical Wiring Code (LEWC) specifies the code of practice for the distribution of electrical energy in and around all types of structures including residential and commercial premises, public buildings, factories, construction sites, farmhouses, booths, temporary installations and playgrounds.

1.1.1.2 The LEWC states the standards and main requirements for ensuring that electrical wiring systems are safe for people, livestock and property from the use of electricity, including safety against electric shocks, burns and fire.

1.1.1.3 The LEWC further provides the general technical guidelines for implementation of the following statutory requirements established by the LERC:

(a) the Electrical Wiring Regulations and

(b) the Certification and Licensing of Electrical Professionals and Contractors Regulations.

1.1.1.4 Consequently, enforcement of compliance with the LEWC shall emanate from the implementation and enforcement of compliance with the relevant aspects of the Regulations cited in clause 1.1.1.3.

1.1.1.5 This LEWC is issued in line with the goals of the National Energy Policy (NEP) as stated in Section 2.1.14 of the ELL and it is based on the mandates of the LERC as provided under Chapter 3 Section 3.3: A. (5), (6) & (8) of the ELL, hereinafter referred to as the Law.

1.1.2 Scope and application

1.1.2.1 The LEWC applies to:

(a) All low voltage electrical installations in buildings including residential, commercial and public premises, factories and industrial undertakings in which the declared voltages do not normally exceed 1kV AC or 1.5kV DC between conductors and 600V AC or 900V DC between conductors and earth and in accordance with the LS IEC 60364 (All parts);

(b) High voltage fixed electrical installations in buildings including residential, commercial, and public premises, factories and industrial undertakings in which the declared voltages exceed 1kV AC or 1.5kV ripple-free DC and in accordance with the LS IEC 61936-1; and

(c) electrical installations supplied from an external source or from a private generation plant.

1.1.2.2 The LEWC is not intended either to take the place of detailed specifications and

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designs or to instruct untrained persons, as the codes are supplementary to any existing statutory regulations.

1.1.2.3 Only proven and established materials, appliances and methods are considered herein, but this does not exclude the use of other materials and methods that may from time be permitted and authorized by the electricity service providers.

1.1.2.4 Any installations not covered by the LEWC shall be in accordance with the appropriate Code of Practice.

1.1.3 Exclusions

1.1.3.1 The LEWC does not cover the following types of installations:

(a) Circuits for telecommunication, radio, telephone, bell and call, sound distribution, fire alarms and emergency lighting circuits and equipment which are supplied with electricity from a safety source (and not fed directly from a public or private power distribution source);
(b) Internal wiring of manufactured apparatus which is not wired on site;
(c) Electrical equipment of motor vehicles (Caravans excluded);
(d) Fixed electrical installations in mobile units such as aircrafts and sea-going vessels; and
(e) Electrical installations at mines and quarries.

1.1.4 Structure of the Liberia Electrical Wiring Code (LEWC)

1.1.4.1 The Parts of the LEWC are generally organized according to the functional requirements by which they are to be implemented.

1.1.4.2 Part A contains the purpose and legal basis of the LEWC, the scope of application and the scope of practice covered and, arrangements for enforcement of compliance of the LEWC through the enactment of the Electrical Wiring Regulations and the Certification and Licensing of Electrical Professionals and Contractors Regulations by the LERC.

1.1.4.3 Part B of the LEWC elaborates guidelines for technical design considerations and specifies some general safety requirements and safety practices in the conduct of electrical wiring of installations.

1.1.4.4 Part C, details electrical installation arrangements including requirements for isolation & switching, protective measures and characteristics of protective devices and their deployment to ensure safety of electrical operations and safe utilization of electricity supply.

1.1.4.5 Part D specifies requirements and guidelines for selection and installation of conductors and cable installation hardware and accessories, requirements for wiring of specific installations and equipment including renewable energy power system wiring and installation practices.

1.1.4.6 Part E provides detailed procedure and requirements for Inspection, Testing and Certification as a precondition for energization of new and altered/repaired

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electrical installations and a requirement for periodic inspection, testing and certification throughout the lifespan of an electrical installation.

1.1.4.7 Part F provides meanings and definitions for special words and technical terms used in the text to bring out the meanings in the context that they have been used in the LEWC.

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1.1.5 Acronyms & Abbreviations

In this Liberia Electrical Wiring Code, the following abbreviations mean:

ABC	Aerial Bundled Cable
AC	Alternating Current
AFDD	Arc Fault Detection Device
ANSI	American National Standards Institute
cpc	Circuit protective conductor
CSA	Cross-sectional area
CT	Current Transformer
DC	Direct Current
EDL	Electric Discharge Lighting
ELL	Electricity Law of Liberia
LEWC	Liberia Electrical Wiring Code
GI	Galvanized iron
GoL	Government of Liberia
HBC	High Breaking Capacity
HV	High Voltage
IEC	International Electro-technical Committee
IET	Institution of Engineering and Technology
kVA	kilovolt-ampere, or one thousand volt-amperes
kVar	Kilovar, or one thousand volt-amperes of reactive power
kW	Kilowatt or one thousand watts of active electric power
kWh	Kilowatt-hour or one thousand watt-hours of electrical energy
LEC	Liberia Electricity Corporation
LERC	Liberia Electricity Regulatory Commission
LS	Liberia Standard
LSC	Luminaire support coupler
LV	Low Voltage
MCB	Miniature Circuit Breaker
MCCB	Molded Miniature Circuit Breaker

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MGC	Mini Grid Code
MICC	Mineral-insulated Copper-clad
MME	Ministry of Mines and Energy
MOL	Ministry of Labor
MV	Medium Voltage
MW	Megawatt, one million watts of active electric power
NEC	National Electrical Code (USA)
PITC	Periodic Inspection, Testing & Certification
PEN	Protective Earth Neutral
PME	Protective Multiple Earthing
PTW	Permit-to-Work
PV	Photovoltaic
PVC	Polyvinyl chloride
RCBO	Residual Current Breaker with integrated Overcurrent protection
RCCB	Residual Current Breaker without integrated Overcurrent protection
RCD	Residual Current Device
SELV	Separated Extra-low Voltage
STC	Standard Test Conditions
TLC	The Learning Channel
TRS	Tough Rubber-sheathed
UL	Underwriters Laboratories
VRI	Vulcanized Rubber Insulated
XLPE	Cross linked polyethylene

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PART B

CODE 2: TECHNICAL DESIGN CONSIDERATIONS

2.1 Technical Designs

2.1.1 General

2.1.1.1 An electrical installation shall be designed by an electrical professional of appropriate grade to provide designs that ensure –

(a) the protection of persons, livestock, and property in accordance with the Electrical Wiring Regulations, and

(b) the proper functioning of the electrical installation for the intended use.

2.1.1.2 The graphical symbols to be used in all drawings, wiring plans and other technical designs relating to the implementation of this LEWC shall be in accordance with Liberian Standards as specified by the Electrical Wiring Regulations.

2.1.2 Commercial purpose installations

2.1.2.1 The design of a building meant for commercial purposes shall make provisions for sub-metering.

2.1.2.2 The sub-meters provided for and installed in commercial buildings shall meet the meter standards prescribed by the Liberia Standards Authority, and the metering requirements as prescribed by the Liberia Electricity Grid Code and the Electricity Distribution Code.

2.1.3 Large installations

2.1.3.1 In all large installations, except where a substation is provided, a separate switch room shall be provided as close as possible to the electrical load center.

2.1.3.2 The switch room shall be placed in such a position that rising ducts may readily be provided therefrom, to the upper floors of the building in one straight vertical run.

2.1.3.3 In larger buildings, more than one rising duct and horizontal duct may be required for running cable, from the switch room to the foot of each rising main.

2.1.3.4 Suitably segregated cable ducts shall be reserved for the electrical services including low and extra-low voltage installations.

2.1.4 Substations

2.1.4.1 Provision for accommodation of substation, transformer, switch room, lift wells and other equipment rooms, service cable ducts, rising mains, sub-distribution boards, openings and chases in the floor and walls for all required electrical installations shall be specified at planning stage by the design engineer.

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2.1.4.2 A substation for a group of buildings shall be at the load center located on the ground floor.

2.1.4.3 A substation in a multi-story building shall be installed at the lowest floor level, with direct access from the street for installation or removal of equipment.

2.1.4.4 The floor level of the substation or switch room shall be above the highest flood level of the locality with a load center between the geometrical center and the air-conditioning plant room.

2.1.4.5 A substation shall have the following rooms:

(a) switchgear room;

(b) transformer room determined by the rating of the transformer; and

(c) stand-by generator room determined by the rating of the generator.

2.2 Planning and Designing

2.2.1 Preliminary design considerations

2.2.1.1 The design and plan of an electrical installation shall consider all the prevailing conditions which may include:

(a) the type of supply;

(b) the envisaged load having regard to the requirements of the owner or occupant;

(c) the probable modifications and future extensions;

(d) the degree of electrical and mechanical protection necessary; and

(e) with due reference to owner's discretion,

(i) the probable operation and maintenance cost considering the electricity supply tariffs available;

(ii) the relative cost of various alternative methods; or

(iii) the need for radio and telecommunication interference abatement.

2.2.1.2 The electrical layout shall be considered after proper locations of all outlets for lamps, fans, and appliances, both fixed and portable, have been selected and best methods of wiring determined.

2.2.1.3 Before commencement of works, runs of wiring and exact positions of points of switchboxes and other outlets shall be marked on the plans of the building and endorsed by the electrical professional for submission to the appropriate authority as part of the building or installation permit approval process.

2.2.2 Basic design information requirements & markings

2.2.2.1 The information required as a basis for design shall be:

(a) nature of current, whether AC or DC;

(b) nature and number of conductors—

(i) for AC:

- phase conductor;

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- neutral conductor; or
- protective conductor; and

(ii) for DC:

- positive conductor; or
- neutral conductor;

(c) voltage and voltage tolerances;
(d) frequency and frequency tolerances;
(e) maximum current allowable;
(f) prospective short-circuit current;
(g) nature of demand;
(h) emergency supply or supplies; and
(i) environmental conditions.

2.2.2.2 Every electrical equipment shall bear the following markings:

(a) the manufacturers name, trademark or other recognized symbol of identification;
(b) catalogue number or type;
(c) voltage;
(d) rated load amperes;
(e) watts, volt-amperes or horsepower;
(f) whether the equipment is for AC, DC or both;
(g) number of phases;
(h) frequency in Hertz;
(i) rated load speed in revolutions per minute;
(j) designation of terminals; and
(k) whether the equipment is for continuous or intermittent duty.

2.2.2.3 Each service box or panel, at the time of installation, shall be marked in a conspicuous, legible and permanent manner to clearly indicate the maximum rating of the overcurrent device which may be used for the installation.

2.2.2.4 Subject to clause 2.2.2.3, at each distribution point, circuit breakers, fuses and switches shall be marked in a conspicuous and legible manner indicating—

(a) the installation or portion of installation they protect or control; and
(b) the permitted maximum rating of overcurrent device.

CODE 3: GENERAL SAFETY REQUIREMENTS & PRACTICES

3.1 Safety Principles

3.1.1 General

3.1.1.1 Every installation shall comply with the specific requirements of this LEWC, and the Electrical Wiring Regulations based on the general principles established in this Code 3.1.

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3.1.2 Design, construction & installation

3.1.2.1 For the purpose of maintenance, it is important (during the design, construction & installation) to ensure the safety of persons approaching electrical equipment to work on it or attend to it.

3.1.3 Workmanship & material

Workmanship

3.1.3.1 Good workmanship and suitable materials shall be used in the construction of electrical installations. The installation of electrical equipment must take account of manufacturers' recommendations.

3.1.3.2 Every piece of electrical apparatus which requires operation or attention in normal use shall be so installed that adequate means of access and working space are afforded for such operation or attention.

3.1.3.3 Every electrical joint and connection shall provide durable electrical continuity, insulation and adequate mechanical strength.

3.1.3.4 Every switch intended to be used for breaking a circuit and every circuit-breaker shall be constructed or installed in a manner that ensures that it is not left in partial contact.

3.1.3.5 Every flexible wire for portable apparatus shall be connected to the system either by efficient permanent joints or connections, or by a properly constructed connector.

3.1.3.6 Particular attention shall be paid to the workmanship employed in making joints, terminations and enclosures for the wiring installations.

Material

3.1.3.7 All materials chosen and used in an electrical installation shall be purposely designed for the intended application and shall be mechanically and electrically protected:

(a) not to cause harmful effects to other equipment,
(b) to prevent danger from shock, burn or other injury to persons, or
(c) from undue fire risk or other electrical hazard to life and property.

3.1.3.8 All electrical apparatus and conductors shall be of such construction and size for the maximum power intended as to prevent excessive temperature rise while in service (either during normal operation or fault condition) and shall be installed as to prevent danger to life and property so far as is reasonably practicable.

3.1.3.9 Electrical conductors selected for an electrical installation shall be effectively insulated and shall be of sufficient current-carrying capacity for the intended purpose.

3.1.3.10 Special consideration shall be given in choosing all electrical apparatus(es), conductors and other materials for installations intended to be exposed to weather, water, corrosive atmospheres, or other adverse conditions to be

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adequately designed and protected as may be necessary to prevent danger.

3.1.3.11 Where the conditions comprise exposure to inflammable surroundings or an explosive atmosphere, the conductors or apparatus(es) shall be protected by a flame proof enclosure of appropriate construction to prevent danger in accordance with guidelines provided under code 8.9.5.

3.1.4 Protection

3.1.4.1 Electrical equipment shall be mechanically and electrically protected to prevent danger from shock, burn, or other injury to persons or damage to property or from fire of an electric origin.

3.1.4.2 Mechanical protection includes the provision of barriers, enclosures, protective covers, guards and means of identification, the display of warning notices and the placing of equipment out of reach.

3.1.4.3 Where it is necessary to remove barriers or open enclosures, protective covers, and guards, it shall be made possible only by use of a key or tool.

3.1.4.4 Electrical protection includes the provision of isolation, protective devices and earthing facilities as well as equipotential bonding of all the exposed conductive parts and extraneous conductive parts.

3.1.4.5 Any metalwork, other than the current-carrying conductor, that is enclosing, supporting or otherwise associated with such conductor shall, where necessary to prevent danger, be efficiently connected with earth.

3.1.4.6 Where the voltage exceeds low voltage, the metalwork shall be efficiently earthed independently of any flexible metallic cover of the conductors and any flexible cover shall be independently earthed.

3.1.4.7 A lamp holder shall not be in metallic connection with the guard or other metalwork of a portable or pendant lamp.

3.1.4.8 Every circuit shall be protected against the persistence of such excess currents as might cause danger, and circuit-breakers or fuses provided for this purpose shall have a breaking capacity related to the maximum fault current that can flow in the circuit concerned.

3.1.4.9 Suitable precautions shall be taken where a reduction in voltage, or loss and subsequent restoration of voltage, could cause danger.

3.1.4.10 Any portable apparatus and its flexible wire shall be controlled by efficient means suitably located and capable of cutting off the supply.

3.1.4.11 A fuse shall not be fitted with a fuse-element larger than that for which the fuse is designed.

3.1.4.12 Where one of the conductors of a system is connected to earth, neither a protective device nor single-pole switch shall be placed in such conductor or any branch of the conductor other than a link for testing/emergency purposes or a switch for use in controlling a generator.

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3.1.4.13 Effective means for isolation of supply, suitably placed for ready operation, shall be provided for cutting off voltage supply from every part of the system and all electrical apparatus as may be necessary to prevent danger.

3.1.5 Switchboard/Switchgear

3.1.5.1 Each switchboard shall be controlled by a suitable isolating switch or circuit breaker and the general arrangement of switchboards shall ensure that:

(a) all parts which may have to be adjusted or handled are readily accessible;
(b) the course of every conductor may, when necessary, be readily traced;
(c) conductors that are not arranged for connection to the same system are kept well apart, and can, where necessary, be readily distinguished; and
(d) all bare conductors are placed and protected as to prevent danger from accidental short-circuit.

3.1.5.2 The base of a panel shall be effectively sealed against the ingress of vermin and termites, and any ventilation louvers shall be backed by brass fine mesh gauze or any other non-corrosive material to exclude vermin and termites.

3.1.6 Identification

3.1.6.1 Each switch, fused switch, switch-fuse, circuit breaker, busbar chamber, check meter and distribution board shall be properly labelled on the front cover to indicate the circuit name or number, the rating of the fuse or circuit breaker, and the purpose of each circuit (e.g., lighting, socket outlet, pumps, lifts etc.).

3.1.6.2 For fuses and circuit breakers fitted in a distribution board which are not visible without opening or removing the front cover of the distribution board, labels shall be fixed inside the distribution board in such a manner as to allow easy identification of the individual fuses or circuit breakers when the front cover is opened or removed.

3.1.6.3 For the live parts of an item of equipment or enclosure, a label shall be fixed in such a position to warn any person gaining access to the live parts, of the need to take special precautionary measures and to operate the designated isolating devices.

3.1.6.4 Labels shall be legible, durable and must be securely fixed to the equipment. Engraved labels and paper labels with a cover sheet of rigid transparent plastic, permanently glued or fixed to the surface of the equipment are also acceptable. For indoor application, the use of paint marking on the equipment is also acceptable.

3.1.6.5 Labels for identification or warning purposes shall be written in the English language.

3.1.7 Inspection & testing

3.1.7.1 Electrical equipment shall be constructed or installed in such a way that they are capable of being inspected and tested.

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3.1.7.2 No additional installation or circuit, intended for either temporary or permanent connection with the public supply shall be made without the permission of the Service Provider in writing.

3.1.7.3 Subject to procedures outlined under Part E, on completion of an installation or an extension of an existing installation, appropriate inspection and tests shall be carried out, to verify so far as is reasonably practicable that the requirements of the LEWC and the Electrical Wiring Regulations have been met.

3.1.7.4 A person responsible for the installation of any new or additional electrical apparatus(es) or circuit shall give, in writing to the Service Provider, notice of commencement and completion of every such installation for connection with the public supply and shall afford the Service Provider's inspector full facilities for inspecting or testing the work during and after completion.

3.1.7.5 An assessment shall be made of any characteristics of the equipment (or additional installation) likely to:

(a) have harmful effects on other installed electrical equipment, or
(b) impair electrical power supply services.

3.1.7.6 Subject to clause 3.1.7.5, the characteristics of interest for assessment may include but not be limited to the following:

(a) over voltages;
(b) under voltages;
(c) fluctuating loads;
(d) unbalanced loads;
(e) power factor;
(f) starting currents;
(g) harmonic currents;
(h) DC feedback;
(i) high-frequency oscillations; and
(j) necessity for additional connection to earth.

3.1.8 Switch room/substation – High voltage

Facilities for locking

3.1.8.1 Every switch room or substation shall have suitable means of entrance/exit that is arranged to prevent unauthorized entry but must always give authorized persons ready access.

3.1.8.2 For preventing unauthorized entry, or access to LV installations, the display of suitable warning notice is acceptable provided that the equipment is not readily accessible to the public. In the case of HV installations, locked enclosure with suitable warning notice shall be provided.

3.1.8.3 Where an entrance or exit of a switch room or substation is provided with locked doors or gates, the arrangement of the lock shall be such that it requires a key to open the door or gate from outside.

3.1.8.4 Every HV switch room or substation, except when manned, shall be kept locked

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and a duplicate key made available for emergency purposes in a key box at a designated location such as in the general office or plant manager room of each plant or depot. All other keys for use in the HV switch room or substation shall be kept under the control of a responsible person.

3.1.8.5 In exceptional cases, a key may be held by a person whose duties require him to have frequent access to a HV switch room or substation. In such a case, that person shall obtain a written authorization from the responsible person stating the duties for which that person is required to hold the key.

Arrangement of entrance/exit

3.1.8.6 At least one exit of a main switch room or substation shall be designed and installed to open outwards to serve as an emergency exit and shall be clearly marked or identified.

3.1.8.7 The main switch room shall be where the point of electricity supply:

(a) Is electrically nearest to the source end of the service provider's system at which a particular consumer's load, or any other loads are or may be connected; or

(b) Is taken directly from the consumer's transformer.

3.1.8.8 Conductors near the entrance/exit of a switch room or substation shall be so arranged or protected that there is no risk of accidental contact of any live metal by any person entering or leaving.

3.1.8.9 To always provide free and ready access for the maintenance and operation of the electrical equipment contained in a switch room or substation, every entrance/exit of a switch room or substation shall be kept free of any obstruction including:

(a) locking facilities other than those in accordance with clause 3.1.8.2;

(b) structures, goods, and materials: and

(c) litter or waste, which impedes the access to the switch room or substation from a public area.

Illumination and ventilation

3.1.8.10 Suitable lighting giving a minimum illumination level of 150 lux measured at floor level in each switch room or substation and an average vertical illumination level of 120 lux minimum shall be provided to allow for the proper operation of electrical equipment.

3.1.8.11 Where electrical equipment in the switch room or substation is required to be operated in case of mains power failure, adequate emergency electric lighting independent of the mains supply and capable of operation for a minimum period of 30 minutes shall be provided.

3.1.8.12 Despite provisions in clauses 3.1.8.10 & 11, additional lighting shall be provided above the specified minimum levels of illumination for maintenance purposes.

3.1.8.13 Suitable ventilation or air-conditioning shall be provided to prevent the development of high ambient air temperatures around the electrical equipment in excess of those permissible for such equipment.

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Prohibition of storage

3.1.8.14 A switch room or substation must not be used for storage purposes other than storage of the tools and spare parts used for the operation and maintenance of the switchgear inside it.

3.2 Safety Practices and Precautions

3.2.1 General safety practices

3.2.1.1 In addition to the safety principles and requirements specified under Code 3.1 and other parts of this LEWC, the following general safety practices shall be observed for work on electrical equipment:

(a) Check before acting;

(b) Isolate and lockout;

(c) De-energize before work; and

(d) Others.

Check before Act

3.2.1.2 The scope of work and relevant target circuit for work shall be checked before starting any electrical work.

3.2.1.3 Subject to clause 3.1.8.10, suitable lighting and adequate illumination must be provided for the workplace.

3.2.1.4 The condition of tools and instruments shall be checked before carrying out electrical work.

Isolate and Lockout

3.2.1.5 The circuit or equipment earmarked for maintenance shall be isolated as far as practicable prior to commencement of work.

3.2.1.6 The relevant isolator shall be identified and locked out and a suitable warning notice placed close to the isolator.

De-energize

3.2.1.7 The circuit/equipment to be worked on must be checked to ensure that it is dead.

3.2.2 Other safety practices

3.2.2.1 Other safety practices shall include the following:

(a) Workplace must be kept clean and tidy.

(b) Hands shall be kept away from any circuit or equipment or extraneous conductive parts that are not being worked on.

(c) Unauthorized persons must not stay in the workplace.

(d) The requirements stated in any related safety procedures and checklist shall be followed.

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(e) Electrical installations, including but not limited to those newly installed, maintained, repaired, or tripped under fault conditions, must be properly inspected and tested prior to energization.

3.3 Safety Precautions for Work on Low Voltage Installation

3.3.1 General

3.3.1.1 An electrical contractor shall appoint a responsible electrical professional of appropriate grade to take charge of electrical work to ensure the quality of the electrical installations and safety of the work.

3.3.1.2 Suitable and adequate personal protective equipment and proper tools shall be used in carrying out electrical work. [A list of standards for common personal protective equipment and tools for electrical work is provided as part of the references in Appendix 3].

3.3.1.3 Where practicable, work on LV electrical equipment shall be carried out after the electrical equipment has been isolated.

3.3.1.4 Where danger cannot be avoided for work on energized equipment, the electrical equipment must be isolated and verified as dead with a voltage indicator and a *Permit-to-Work* (sample of which is shown in Appendix 1a) issued.

3.3.1.5 Where work is to be done on dead LV electrical equipment that is controlled by a circuit breaker or switch:

(a) the circuit breaker or switch shall be locked off where practicable:
(b) a warning notice for repair shall be affixed; and
(c) the keys for the locks shall be kept under the control of a responsible person.

3.3.2 Conditions and safety precautions for live work

3.3.2.1 Live work shall not be performed unless:

(a) it is necessary in the interests of safety, whether or not electrical safety, for the work to be performed while the electrical equipment is energized (e.g. work on hospital equipment); or
(b) a supply of electricity is essential for the proper performance of the electrical measurement (e.g., testing and fault finding); or
(c) there is no reasonable alternative to perform the electrical work by live work (e.g., widespread outages of a building would occur if live work is not allowed); or
(d) it is justified and approved by the electrical professional (person in-charge), electrical contractor (responsible person) and owner of the installation (e.g., serious public inconvenience would arise from isolating the circuits).

3.3.2.2 A person shall not carry out low voltage live work except in accordance with an approved procedure, which shall ensure adequate protection from danger from electric shock and inadvertent short-circuiting of the conductors.

3.3.2.3 Where low voltage live work is to be carried out, the responsible person and person in-charge of the working party shall carry out an assessment of the site

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conductors, and the work shall only commence where site conditions enable work to be done safely.

3.3.2.4 Every person who carries out live working shall be a competent person and shall have received appropriate training in the particular low voltage live working procedure, and adequately instructed by the person in-charge of the working party.

3.3.2.5 Tools and equipment approved for that purpose shall be the only tools used for work on, or the testing of low voltage apparatus and conductors.

3.3.2.6 If the site conditions become unsafe, low voltage live working shall be suspended and the following requirements assessed:

(a) the apparatus to be worked upon shall be visually inspected to ascertain if it is in a satisfactory condition;
(b) there shall be adequate working space and safe means of escape;
(c) the working space and the apparatus to be worked on shall be adequately illuminated; and
(d) if the work is outdoors, the weather conditions shall not be unduly adverse.

3.3.2.7 A person shall not carry out work which involves or is equivalent to a manipulation of bare live conductors, unless accompanied by another person who shall be available to render or obtain assistance in an emergency.

3.3.3 Work involving the use of electric-arc welding set

3.3.3.1 Welders must be properly trained to avoid direct contact with exposed energized parts of an electrode clamp or a welding rod such as by wearing protective clothing and gloves.

3.3.3.2 The work piece to be welded shall be effectively and electrically connected to the welding return before welding work is commenced. [Note: Please refer to the relevant codes of practice and/or guidelines of the Ministry of Labor (MOL)].

3.3.4 Precautions for supply connection

3.3.4.1 Temporary or permanent supply shall not be connected to a circuit unless:

(a) the circuit and its final circuits, if any, are completed and properly terminated, or
(b) the part(s) of the circuit or its final circuits which have not been completed, are disconnected or isolated with its associated isolating devices locked off.

3.3.5 Precautions for major alteration

3.3.5.1 Before a major alteration is carried out on a circuit such as repositioning of a circuit, the circuit shall be either:

(a) disconnected from the supply source at the distribution board concerned; or
(b) isolated with the isolating device locked off or its operation handle removed.

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3.3.5.2 The key or handle (of isolating device), must be non-interchangeable with any others used for a similar purpose on other parts of the installation, shall be kept by the responsible person.

3.3.6 Precautions for work inside a false ceiling

3.3.6.1 A task-specific risk assessment shall be conducted by a competent person assigned by an electrical contractor or the owner of the fixed electrical installation to identify all potential hazards associated with work inside false ceiling before the commencement of work.

3.3.6.2 A electrical contractor or the owner of fixed electrical installation shall formulate appropriate method statements with safety procedures and safety measures for the work in accordance with the relevant risk assessments, and provide necessary safety information, instruction, training and supervision to the persons performing such work to avoid danger.

3.3.6.3 The scope of work and circuits of energized electrical installation at the place of work and in the vicinity of the work area must be identified.

3.3.6.4 Suitable personal protective equipment and testing equipment shall be provided to and properly used by the persons performing the work.

3.3.6.5 The risk of inadvertent contact with live conductors or live part of energized electrical installation at the place of work and in the vicinity (i.e. within 1.5m) of the work area as well as its access path shall be assessed and eliminated.

3.3.6.6 Entering into or working on fragile false ceiling or similar unsafe places is prohibited. If access to and working on such places are required, suitable means of access, means of support or working platforms must be provided and properly used.

3.3.6.7 Subject to clause 3.1.8.10, the work area and its access path shall be suitably lit.

3.3.7 Use of portable equipment

3.3.7.1 Portable equipment of electrical work shall be regularly checked and maintained, especially for the connections at the plug, to ensure that the equipment is in safe working order at all times.

3.3.8 Work-at-height

3.3.8.1 Where electrical work cannot be safely done on or from the ground or from part of a permanent structure, reference shall be made to the requirements set out in the relevant publications of the MOL.

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3.4 Safety Precautions for Work on High Voltage Installation

3.4.1 General

3.4.1.1 Precautionary measures, including those applicable under Code 3.3, shall be taken for work on HV installation and the procedure of work shall be such that no danger is posed to persons or property.

3.4.1.2 Work on HV installations shall be in accordance with procedure stated in this Code 3.4 and relevant international standards, manufacturers' recommendation, operations, and maintenance instructions.

3.4.1.3 A responsible person shall be appointed to take charge of the operation and maintenance work of the installation.

3.4.1.4 Equipment that is considered by the responsible person to be in a dangerous condition shall be isolated elsewhere and action taken to prevent it from being reconnected to the electricity supply.

3.4.2 Access to HV enclosures

3.4.2.1 No person, except a responsible person or a person having the permission of the responsible person, shall enter a HV enclosure, and where danger may exist, no one shall enter that HV enclosure unaccompanied.

3.4.2.2 The areas containing exposed HV live conductors, connected test equipment or test connection shall be screened or fitted with barrier with appropriate label or sign attached to avoid unauthorized access.

3.4.2.3 Subject to clauses 3.1.8.4 & 5, a separate key cabinet shall be provided in a HV enclosure containing keys for locks used to lock:

(a) out isolators or switches; or
(b) switchgear in earthed position; or
(c) other safety devices inside the enclosure.

3.4.2.4 The cabinet referred to in clause 3.4.2.3 shall be equipped with hooks labelled to match the items of equipment and shall be locked with a master lock which key shall be issued to the responsible person only.

3.4.2.5 A logbook (sample of which is shown in Appendix 2a) shall be maintained inside the equipment safety key box to record time, date, and details of the padlock movements whiles another logbook (which sample is shown in Appendix 2b) shall be kept inside the HV enclosure to record time, date and details of the access to the enclosure.

3.4.2.6 An underground substation that is not easily and safely accessible shall be provided with adequate means of access by a door or trap door, with a staircase or ladder securely fixed and placed to ensure that no live part of any switchboard or any bare conductor is within the reach of a person on the substation.

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3.4.2.7 Unless alternative approved safety procedures apply because of special circumstances, before access or work is carried out in a HV enclosure protected by automatic fire extinguishing equipment:

(a) the automatic control shall be rendered in-operative, and the equipment left on manual control mode, and a caution notice attached;

(b) the precautions taken to render the automatic control in-operative and the conditions under which it may be restored shall be noted on a safety document or written instruction issued for such access or work or other activity; and

(c) the automatic control shall be restored immediately after the personnel engaged in the work have withdrawn from the HV enclosure and the access doors closed and locked.

3.4.2.8 Only approved portable fire extinguishers shall be made available and shall be the only extinguishers to be used near live apparatus and conductors.

3.4.2.9 After an explosion, fire or discharge of a fire extinguisher in an enclosed space, the space shall be adequately ventilated before entry by any personnel.

3.4.2.10 Instructions as to the treatment of persons suffering from electric shock shall be affixed in all premises where electrical energy is generated, transformed, or used.

3.4.3 Work on HV electrical equipment

General

3.4.3.1 With the exception of cases where *Sanction-for-Test* is issued with only the test voltage encountered, work involving the handling of live parts or working within touchable distance, direct or indirect, of live parts is not permitted.

3.4.3.2 No person shall carry out maintenance, repair, cleaning and testing on any part of HV electrical equipment unless such parts of the electrical equipment are:

(a) dead, isolated from live conductors and all practical steps taken to lock off from live sources;

(b) effectively earthed at all points of disconnection of supply to such apparatus or between such points and the points of work;

(c) fixed with warning notices for repair, barriers and/or screens; and

(d) released to be worked on by issue of a *Permit-to-Work* (sample shown in Appendix 1a) or a *Sanction-for-Test* (sample shown in Appendix 1b) whichever is applicable.

3.4.3.3 All working on or testing of HV equipment connected to a system shall be authorized by a *Permit-to-Work* or *a Sanction-for-Test* respectively following the procedures set out in Code 12.3 and it is the duty of the responsible person to ensure that all the provisions in clause 3.4.2.2 and Code 12.3 are complied with prior to the issue of the *Permit-to-Work* or *Sanction-for-Test*.

3.4.3.4 No hand or tool (unless the tool has been designed for the purpose) shall make contact with any HV conductor unless that conductor has been confirmed dead by the responsible person.

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3.4.3.5 Where the procedures involve the application of circuit main earths, the unauthorized removal of such earths must be prevented, wherever practicable, by the application of safety locks.

3.4.3.6 The spiking of cables must only be carried out by a person who has been specifically trained in the operation of the equipment and in the presence of the Person in-charge.

3.4.3.7 Voltage transformers must not be removed or replaced if any of the windings are energized. If they need to be removed, the equipment supplying the voltage transformer must be isolated and made dead.

3.4.3.8 When withdrawable electrical equipment is disconnected from all supplies and withdrawn from its normal live position, its conductors must be discharged to earth, but need not remain connected to earth. The enclosure and any shutters must be locked off.

Breakers/isolators etc.

3.4.3.9 Before work is carried out on remotely or automatically controlled equipment such as circuit breakers, isolators, tap-changing gear or associated air compressors, all remote-control and automatic features must first be rendered inoperative. No work shall be carried out on the controlling equipment, wiring or relays except by the responsible person, or person in-charge working under the personal supervision of the responsible person.

Busbar

3.4.3.10 When work or test is to be carried out on busbar spouts of multi-panel switchboard, the following operations shall be carried out in strict sequence:

(a) Responsible person shall issue *Permit-to-Work* to cover the work to be done or *Sanction-for-Test* to cover the test to be conducted.

(b) The section of the busbar spouts on which work is to be carried out must be isolated from all points of supply from which it can be made live.

(c) The isolating arrangements must be locked so that they cannot be operated, and shutters of live spouts locked shut and caution signs fixed to the isolating points.

(d) Where applicable, danger signs shall be attached on or adjacent to the live electrical equipment at the limits of the zone in which work is to be carried out.

(e) Busbars shall be checked by means of an approved voltage indicator to verify that they are dead, the indicator itself being tested immediately before and after use. The checking with the voltage indicator must be done on the panel to which the circuit main earths are to be applied and also on the panel on which the work is carried out.

(f) Circuit main earths shall be applied at a panel on the isolated section of the busbar other than that at which work is to be done using the method recommended by the switchgear manufacturers. The insertion of hands or any tool into the contact spouts for this purpose is not an acceptable practice.

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(g) An earth connection shall also be applied to a point as near to the point-of-work as possible;
(h) During the work, where applicable, the earth connection(s) at the point-of-work
    (i) may be removed one phase at a time for work to be done) and
    (ii) must be replaced before another phase earth connection is removed.
(i) On completion of the work, the *Permit-to-Work* must be cancelled.

Voltage transformer

3.4.3.11 When work or test is to be carried out on a feeder or voltage transformer spouts, or on busbar spouts of a single panel, the following operations shall be carried out in strict sequence:
(a) Responsible person must issue *Permit-to-Work* to cover the work to be done or *Sanction-for-Test* to cover the test to be conducted.
(b) The spouts on which work is to be carried out must be isolated from all points of supply from which they can be made live.
(c) The isolating arrangements shall be locked so that they cannot be operated, the shutters of live spouts locked shut and caution signs affixed to all isolating points.
(d) Where applicable, danger signs shall be attached on or adjacent to the live electrical equipment at the limits of the zone in which work is to be carried out;
(e) Spout contacts must be checked by means of an approved voltage indicator to verify that they are dead, ***[NB: the indicator itself must be tested before and after use]***;
(f) The circuit shall be earthed with approved earthing equipment at the point-of-work and where practicable at all points of the isolation from the supply. For earthing of metal-clad switchgear, only approved appliances must be used. The insertion of hands or any tools into contact spouts for this purpose is not an acceptable practice;
(g) During the work, where applicable, the earth connection(s) at the point-of-work
    (i) may be removed one phase at a time for work to be done) and
    (ii) must be replaced before another phase earth connection is removed.
(h) On completion of the work, the *Permit-to-Work* must be cancelled.

Distribution transformer

3.4.3.12 When work or test is to be carried out on the connections to, or the windings of a distribution transformer, the following operations shall be carried out:
(a) Responsible person shall prepare for issue *Permit-to-Work* to cover the work to be done or *Sanction-for-Test* to cover the test to be conducted;
(b) The switchgear or fuse gear controlling the HV windings shall be switched off, and a safety lock and caution sign fitted;
(c) The switch or isolator controlling the LV windings of the transformer shall be switched off, and a safety lock and caution sign fitted, or other physical means used to prevent the switch from being energized during the work;

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(d) Where applicable, danger signs shall be attached on or adjacent to the live electrical equipment at the limits of the zone in which work is to be carried out;
(e) The transformer shall be proved dead at the points-of-isolation if practicable;
(f) An earth shall then be applied to the HV winding via the switchgear and a safety lock fitted. If the proprietary earthing gear is available for the LV switchgear, it must be fitted, and safety locks applied (It is advisable to re-test for dead before fitting this earthing gear).
(g) Prior to handing over of the *Permit-to-Work* the responsible person shall, at the point-of-work and in the presence of the person in-charge, identify and mark the transformer to be worked on.
(h) The *Permit-to-Work* and the key to the key safe shall then be issued to the person in-charge.
(i) If the conductors of the transformer are exposed during the work the responsible person shall confirm it dead via a HV indicator to the satisfaction of person in-charge before any physical contact is made.
(j) The transformer must be isolated from all common neutral earthing equipment from which it may become live. This does not require the disconnection of solidly earthed neutrals or neutral equipment connected solely to the transformer on which work is to be done.

Generator

3.4.3.13 When work or test is to be carried out on the connections to, or the windings of, a generator the following operations shall be carried out:
(a) Responsible person shall issue *Permit-to-Work* to cover the work to be done or *Sanction-for-Test* to cover the test to be conducted.
(b) The switchgear supplied by the HV windings shall be switched off and a safety lock and caution sign fitted. Care shall be taken to ensure that any auxiliary supplies are also isolated with safety locks and caution signs are fitted.
(c) The engine starting mechanism shall be inhibited and safety locks and caution signs fitted to the engine start panel;
(d) Where applicable, danger signs must be attached on or adjacent to the live electrical equipment at the limits of the zone in which work is to be carried out.
(e) The generator shall be proved dead at the points-of-isolation, if practicable.
(f) An earth shall then be applied to the HV winding via the switchgear and a safety lock fitted.
(g) Prior to issue of *Permit-to-Work* the responsible person shall, at the point-of-work and in the presence of the person in-charge, identify and mark the generator to be worked on.
(h) The *Permit-to-Work* and the key to the key safe shall then be issued to the person in-charge.

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(i) If the conductors of the generator are exposed during the work, responsible person must confirm it dead using a HV indicator to the satisfaction of the person in-charge before any physical contact is made.

3.4.4 Permit-to-work/Sanction-for test

3.4.4.1 Before a *Permit-to-Work* or a *Sanction-for-Test* (samples shown in Appendix 1) is issued, responsible person shall identify the equipment on which the work or test is to be undertaken.

3.4.4.2 If the work involves, or may involve, obtaining access to items of equipment over which confusion could occur, the responsible person shall identify such items to person in-charge and apply temporary markings to them.

3.4.4.3 Before issuing a *Permit-to-Work* or a *Sanction-for-Test*, responsible person shall show the person in-charge the isolation and earthing arrangement and indicate the safety arrangements at the points-of- isolation and at the point-of-work or test.

3.4.4.4 Responsible person shall ensure that the person in-charge understands all the relevant safety procedures and precautions.

3.4.4.5 If the person in-charge thereafter accepts the permit or sanction, that person shall countersign all the relevant documentation issued and take responsibility to undertake the defined work or test until the permit or sanction is cancelled.

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PART C

CODE 4: INSTALLATION ARRANGEMENTS FOR CONTROL & PROTECTION OF SUPPLY

4.1 Switchgear Arrangement and Control

4.1.1 Control of installation

4.1.1.1 An electrical installation that receives electricity supply from an external source shall be adequately controlled by a switchgear made up of any combination of the following forms:

(a) a consumer's supply control unit;
(b) a switchboard;
(c) independent switchgears consisting of disconnect switches, circuit breakers or fuses; or
(d) distribution board (fused) and main switch.

4.1.1.2 A switchgear is required both to de-energize equipment or installation to allow work to be done and to clear faults downstream.

4.1.2 Types of supply source and switchgear arrangement

4.1.2.1 The construction or arrangement of main switchgear for the different types of sources of supply and application shall be as follows:

AC Single phase:	Main Switchgear: 2-pole (linked) Fuse in non-earthed conductor.
AC Three phase 3-wire system	Main Switchgear: 3-pole (linked) Fuses in each phase
AC Three phase 4-wire system	Main switchgear: 3 or 4-pole (linked) Fuses in each phase

4.1.2.2 Three phase switchgear terminals shall be connected with phases red, yellow and blue in that order from left to right.

4.1.2.3 All main gear shall be sign-written with the place of isolation where it is remote from isolation.

4.1.2.4 Complete fuse charts shall be fixed in lids or mounted adjacent to all distribution boards.

4.1.2.5 Engraved labels as appropriate from code 11.2.1 shall be attached to all three phase switches and distribution gear.

4.1.3 Supply intake equipment arrangement

4.1.3.1 Equipment installed at the supply intake position for an installation or premise shall be arranged in the following sequence as illustrated in Figures 4-1 and 4-2

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respectively for a residential and industrial installation:

(a) service cable and sealing box, or service line and termination (for overhead service line) as may be required;
(b) service fuses and neutral link of adequate size (or ariel cut-out fuses for overhead service connections);
(c) kilowatt hour meter;
(d) consumer's linked switch;
(e) consumer's main fuse (may be combined with (d) as a fused-switch); and
(f) consumer's circuit fuses.

4.1.3.2 The consumer's main switchgear (referred to as an assembly of items d, e & f) shall be readily accessible to the consumer and situated as near as practicable to the termination of the service provider's service cable or line.

4.1.3.3 The position of the incoming service, service fuses and meter shall be decided by the Service Provider.

4.1.3.4 The consumer's main fuses, provided for in clause 4.1.3.1(e) may be omitted provided that:

(a) the installation is controlled by a combination of a distribution board and main switch, where the distribution board comprises not more than eight fused-ways each rated at not more than 30 Amperes, and
(b) the total connected load is not more than 30 Amperes.

4.1.3.5 Where a switchboard of the metallic clad type, having its busbars totally enclosed in a rigid metal case supplies two or more circuits, means of disconnecting the busbars from the supply shall be provided.

4.1.3.6 Every distribution board shall be connected to either the main switch controlling the supply, or a separate way on a larger distribution board or switchboard.

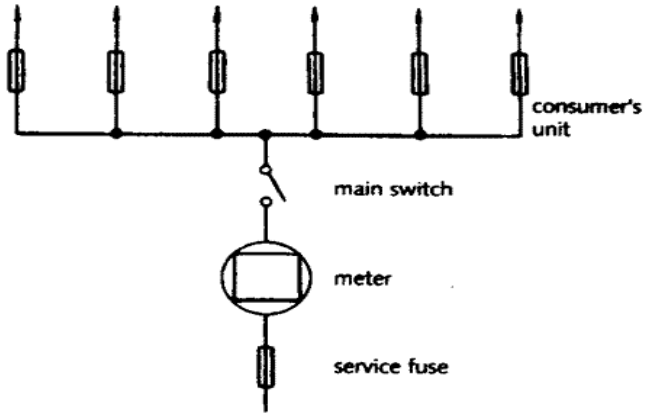

Fig 4-1: Typical arrangement for feeding final circuits in a residential installation

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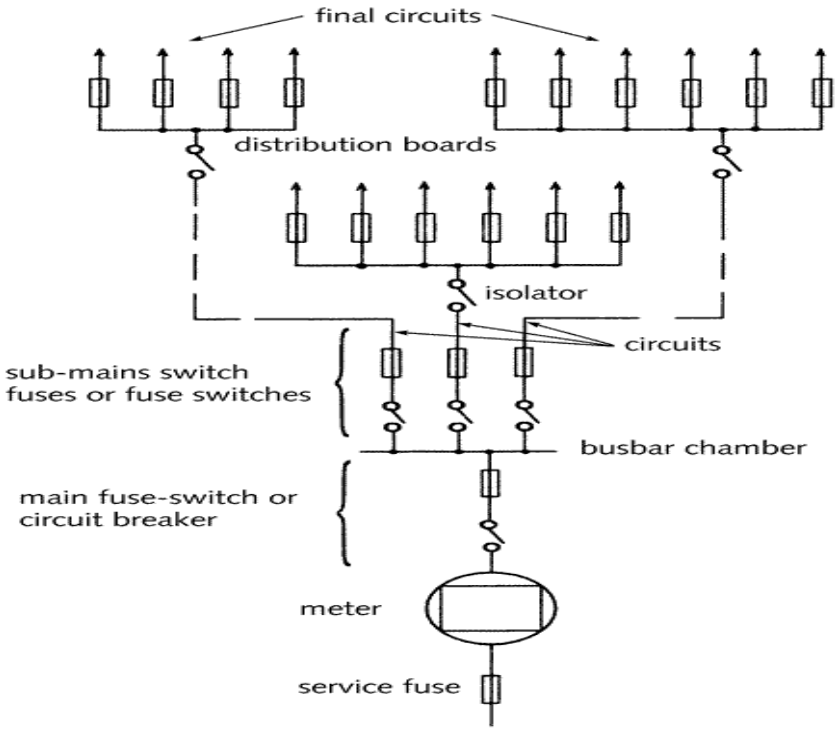

Fig 4-2: Typical arrangement for feeding final circuits in an industrial installation

4.1.4 Switchboards/Switchgear

4.1.4.1 Subject to code 3.1.5, switchboards for the control of equipment rated at 240V/415V shall conform to LS IEC 60439 and panels shall be free standing of uniform height, flush mounted and totally enclosed protection in accordance with LS IEC 60144.

4.1.4.2 The framework for the panels may be fabricated from mild steel sheet of 3mm minimum thickness, or any other appropriate material approved by the Service Provider to provide a rigid structure.

4.1.4.3 All bolts, nuts, screws, hinges and handles shall be corrosion resistant with the interiors furnished with white and the exterior furnished with a light grey shade except the plinth that shall be furnished black.

4.1.4.4 Cabling access from the rear shall be by means of gasketed bolt-on plates, which shall be fitted with handles to facilitate removal or replacement.

4.1.4.5 Access to the cubicles or cubicle compartments for all normal routine maintenance shall be from the front by hinged and lockable doors fitted with neoprene gaskets which shall be termite resistant, and chromium plated lockable tee-type handles.

4.1.4.6 All doors shall be electrically bonded to the main frame, using adequate flexible conductors, protected against mechanical damage.

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4.1.4.7 All locks on a given panel unit shall be operated by the same key.

4.1.4.8 Every multi-compartment control panel shall comprise an assembly of individually constructed cubicles which shall be assembled to include a metallic sheet between adjacent cubicles and shall have at least one empty compartment reserved for future use.

4.1.4.9 Panels shall be readily capable of extension at either end, within the bus bar rating but where panel size is excessive, easily handled sections shall be supplied for site assembly.

4.1.4.10 All busbars shall be made of electro-tinned copper and be of uniform section throughout the length of the panel.

4.1.4.11 The busbars under clause 4.1.4.10 shall be run in a separate screened compartment divided with barriers into compartments and cubicles in the panel, and access to individual compartments shall be via bolt-on cover plates each bearing the legend **"DANGER" – "LIVE BUS-BARS** in white on a red background with a red arrow symbol denoting danger from electric shock.

4.1.4.12 Panels shall be equipped with an electro-tinned earthing strip running the full length of the panel rated to withstand without damage, the thermal and dynamic effects of earth fault currents.

4.1.4.13 The electrical professional or electrical contractor shall be responsible for ensuring that all components, sub-assemblies, including gland plates are solidly bonded to earth using green or yellow insulated copper conductors of appropriate cross-sectional area.

4.1.4.14 Every switchboard having exposed bare conductors shall, where not located in an area or areas set apart for the purpose, be suitably fenced or enclosed.

4.1.4.15 All apparatus pertaining to a switchboard and requiring handling, shall as far as is practicable, be placed or arranged to be operated from the working platform of a switchboard.

4.2 Circuit Arrangement

4.2.1 Division of installation into final circuits

4.2.1.1 An electrical installation shall be divided into final circuits as necessary or practicable, and each final circuit separately protected and controlled to:

(a) avoid danger and minimize inconvenience in the event of a fault, and

(b) facilitate safe operation, inspection, testing and maintenance.

4.2.1.2 A final circuit shall be described either as a radial final circuit or a ring final circuit.

4.2.1.3 The number of final circuits will depend on the types of loads supplied and must be designed to comply with the requirements for overcurrent protection, switching and the current-carrying capacity of conductors.

4.2.1.4 A durable copy of the schedule relating to a schematic wiring diagram shall be displayed within or adjacent to each distribution board.

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4.2.1.5 The schedule shall be a legible diagram using symbols complying with the appropriate Liberia standard as prescribed by the Liberia Electrical Wiring Regulations, a chart or table indicating the following information:
(a) the type of circuit and its composition;
(b) the type of protection against indirect contact; and
(c) the information necessary for the identification of each protective device and its location.

4.3 Basic Requirements of Circuits

4.3.1 Protection

4.3.1.1 Each final circuit shall be protected by an overcurrent protective device with its operating current value closely related to:
(a) the current demand of the current-using equipment connected or intended to be connected to it; and
(b) the current-carrying capacity of the conductor used for the connection.

4.3.1.2 The arrangement provided in clause 4.3.1.1 is required to avoid danger in the event of a fault by ensuring prompt operation of the protective device at the appropriate current value which will otherwise cause damage to the cable/ conductor or the current-using equipment.

4.3.1.3 A fault on one circuit shall not result in the shutting down of any unrelated parts of the installation as far as reasonably practicable.

4.3.1.4 To satisfy the requirement in clause 4.3.1.3, the following is recommended:
(a) fixed lighting fittings of an installation shall be arranged to be fed by two or more final circuits;
(b) lighting final circuits shall be electrically separated from power circuits, but may be connected to bell transformers or electric clocks; and
(c) power circuits for kitchens should be electrically separated from other power circuits.

4.3.1.5 Where the supply is designed to be taken from more than one transformer, interconnection facilities between the main incoming circuit breakers may be provided, if requested by the service provider.

4.3.1.6 Subject to the condition described in clause 4.3.1.5, all incoming and interconnection circuit breakers shall be:
(a) of the 4-pole type interrupting all live conductors (i.e., phase and neutral conductors); and
(b) electrically and mechanically interlocked to prevent the service provider's transformers from operating in parallel.

4.3.1.7 Arc fault detection devices (AFDDs) complying to IEC 62606 may be used to provide additional protection against fire caused by arc faults in final circuits of premises:
(a) with sleeping accommodation (e.g., dwellings, hotels and guest houses);

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(b) for manufacturing or storing of readily combustible substances, or substance liable to spontaneous combustion;
(c) where combustible materials such as wood are used as the main construction materials; and
(d) with endangering or irreplaceable goods.

4.3.2 Control and identification of circuits

4.3.2.1 Each circuit shall be provided with means of interrupting the supply on load, and isolation for electrical servicing and testing purposes without affecting other circuits.

4.3.2.2 Protective devices of each circuit shall be clearly labelled or identified in a permanent manner so that the rating of the devices and the circuits they protect can be easily recognized.

4.3.2.3 Final circuits for emergency lighting, firefighting equipment and fireman's lift shall be electrically separated from one another and from other circuits.

4.3.3 Load distribution & arrangement of neutral conductor

4.3.3.1 Single phase loads in an installation with a three-phase supply shall be evenly and reasonably distributed among the phases.

4.3.3.2 The neutral conductor of a:
(a) single-phase circuit shall not be shared with any other circuit.
(b) three-phase circuit shall only be shared with its related phases in a three phase four wire system.
(c) polyphase circuit shall have at least the full size of current-carrying live conductors to cater for any imbalance or harmonic currents which may occur in normal services.

4.3.3.3 Subject to clause 4.3.3.2.(c), for a balanced three-phase system where the total harmonic distortion due to third harmonic current is greater than 15% of the fundamental line current, the rating factors given in Table 4-1 shall apply (for selection of the neutral conductor).

Table 4-1: Rating factors for triple harmonic currents in 4-core and 5-core cables

Third harmonic content of line current* %	Rating Factor for cable size selection based on:	
	Line current	Neutral current
0-15	1.0	-
>15-33	0.86	-
>33-45	-	0.86
>45	-	1.0

** The third harmonic content expressed as total harmonic distortion*

4.3.4 Ring final circuit arrangement

4.3.4.1 The circuit conductor of a ring circuit shall be run in the form of a ring, commencing from the origin of the circuit in the distribution board, looping into the terminal of

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socket outlets connected in the ring, and returning to the originating point of the circuit as illustrated in Figure 4-3.

4.3.4.2 The circuit protective conductor of a ring circuit (other than formed by the metal coverage or enclosure containing all conductors of the ring circuit) shall also be run in the form of a ring having both ends connected to the earthing terminal at the origin of the circuit.

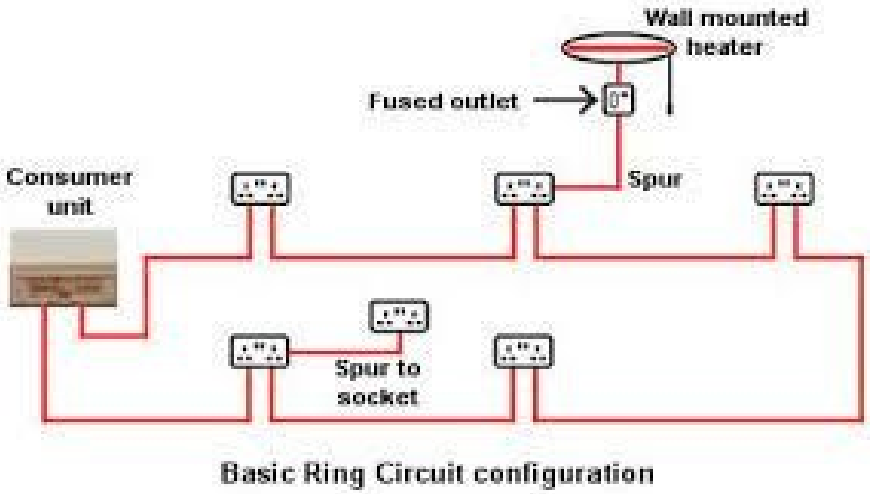
4.3.4.3 When two or more ring final circuits are installed, socket outlets and equipment to be served by these circuits shall be evenly and reasonably distributed among these separate ring final circuits.

4.3.4.4 For a ring final circuit, it is recommended that –

(a) the total number of socket outlets placed on a ring circuit shall not exceed eight (8);
(b) the maximum rating of the fuse or MCB rating shall not exceed 32A; and
(c) the minimum cable size shall be 2.5mm^2.

4.3.4.5 For other ring circuit considerations, it is recommended that the rating of the protective device shall not exceed 0.67 times the rating of the cable (i.e. 0.67 x cable rating).

Figure 4-3 (source: www.diydata.com/electrics/ring-main)



Basic Ring Circuit configuration

4.3.5 Radial final circuit arrangement

4.3.5.1 A radial final circuit conductor shall be run commencing from the origin of the circuit in the distribution board and terminating in the terminal of the last connected socket outlet or connection of equipment on the circuit.

4.3.5.2 For a radial final circuit, it is recommended that –

(a) the aggregate rating of the load on the circuit shall not exceed the rating of the cable; and
(b) the rating of the protective fuse or (miniature) circuit breaker shall also not exceed the rating of the cable.

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Lighting Circuits

4.3.5.3 For residential installations:

(a) the maximum number of lighting points on a circuit shall not exceed ten (10); and

(b) the maximum fuse or MCB rating shall be limited to 6A.

Circuit for Power Outlets (for radial final circuit)

4.3.5.4 General power outlets shall have a minimum fuse or circuit breaker rating of 15A with the following additional recommendations:

(a) the total number of socket outlets on a circuit shall not exceed four (4).

(b) the minimum cable size used shall be 2.5mm^2; and

(c) for guidance, four (4) switchable socket outlets per 10m^2 floor area is recommended.

4.3.5.5 For power outlets with a fuse or MCB rating of 32A:

(a) the maximum number of socket outlets on a circuit shall not exceed six (6); and

(b) the recommended cable size shall be 4mm^2 at the minimum.

4.3.6 Spur circuit connections

4.3.6.1 A final circuit may have spur connections that can be fused or non-fused as illustrated in Figure 4-3. The number of fused spurs connected to a final circuit is unlimited, but the number of non-fused spurs shall not exceed the total number of socket outlets and fixed equipment permanently connected in the circuit.

4.3.6.2 A non-fused spur connection shall –

(a) feed only:

(i) one single or twin socket outlet; or

(ii) one permanently connected equipment; and

(b) be connected to a circuit at:

(i) the terminals of socket outlets; or

(ii) joint boxes; or

(iii) the origin of the circuit in the distribution board.

4.3.6.3 A fused spur shall be connected to the circuit through a fused connection unit, with the rating of the fuse not exceeding that of the cable forming the spur, and not exceeding 13A in any event.

4.3.7 Separate circuits

4.3.7.1 Separate circuits shall be used for:

(a) socket outlets and fixed appliances in kitchens;

(b) electric water heaters;

(c) permanently connected space heaters; and

(d) air-conditioning units.

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Permanently connected equipment

4.3.7.2 Equipment, connected permanently (i.e., not through a plug-socket arrangement) to a final circuit arranged in accordance with Table 4-2 shall be –

(a) locally protected by a fuse of rating not exceeding 13A and
(b) be controlled by a switch in a readily accessible position or
(c) protected by a miniature circuit breaker of rating not exceeding 16A.

Table 4-2: Final Circuits Using 13A Socket Outlets Complying to BS 1363

Type of Circuit	Rating of Overcurrent Protective Device (HBC fuse or Miniature Circuit Breaker) (Ampere)	Min. Copper Conductor Size of Rubber or PVC Insulated Cable for the Circuit and Non-fused Spur (Note) (mm^2)	Maximum Floor Area Served (m^2)
A1 Ring	30 or 32	2.5	100
A2 Radial	30 or 32	4	50
A3 Radial	20	2.5	20

Note: 1. If cables of two or more circuits are bunched together or the ambient air temperature exceeds 30°C the size of conductor should be increased, and appropriate rating factors (obtained from BS 7671:2018 listed as a reference standard in Appendix 3) applied such that the conductor size must correspond to a current-carrying capacity not less than: (i) 20A for A1 or A3 circuits (ii) 30A or 32A for A2 circuits.

2. The conductor size of a fused spur must be determined from the total current demand served by that spur, which is limited to a maximum of 13A. When such spur serves socket outlets, the minimum conductor size is 1.5mm^2 for rubber or PVC insulated cables, copper conductors

4.3.8 Final circuits using USB Outlets to IEC 60950-1

4.3.8.1 Radial final circuit arrangement shall be used for final Universal Serial Bus (USB) circuits.

4.3.8.2 Overcurrent protection shall be provided on the primary side of each USB circuit either as integral parts of equipment or as part of the wiring installation.

4.3.8.3 The installation instructions of the USB circuit shall specify and provide guidance on the type of overcurrent protection to be followed in all situations.

4.3.8.4 USB circuits shall be electrically separated from all power circuits, except final circuits of 13A socket outlets.

4.3.8.5 Where a USB circuit is to be fed from a final circuit of 13A socket outlets –

(a) a fused spur shall be connected to the circuit through a fused connection unit; and
(b) the rating of the fuse shall be in accordance with the manufacturer's recommendation, but certainly not exceeding 13A.

4.3.9 Final circuits using 16A, 32A, 63A or 125A industrial socket outlets to IEC 60309

4.3.9.1 Industrial socket outlets in the LS IEC 60309 category shall be required for use with retaining devices for either indoor or outdoor applications fed from either a single-phase or three-phase supply.

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4.3.9.2 The accepted practice for the final circuits under this code 4.3.9 shall be as follows:

(a) Only radial final circuits shall be used.
(b) Fused or non-fused spur is not allowed.
(c) The current demand of the equipment fed by the circuit shall depend on the type of equipment and the operational requirements.
(d) The maximum rating of the overcurrent protective device shall –
  (i) be 20A for a 16A industrial socket outlet, and
  (ii) not exceed the rating of the socket outlet or the rating of the cable forming the circuit, in the case of the higher rated (32A, 63A or 125A) socket outlets.
(e) The number of socket outlets on the circuit shall:
  (i) be unlimited for 16A industrial outlets, but
  (ii) not exceed one for the higher rated (32A,63A or 125A) socket outlets.

High Voltage Circuit Protection Requirement

4.3.9.3 The setting of the protective device for a HV installation shall be in accordance with the manufacturer's data and shall be well designed to ensure that the fault clearance time is within the equipment rating.

4.4 Current Demand and Diversity Considerations

4.4.1 General

4.4.1.1 Maximum demand *(often referred to as MD)* is the largest current normally carried by circuits, switches and protective devices, excluding the levels of current flowing under overload, short-circuit or other fault conditions.

4.4.1.2 There are limits to how much current a circuit or device can carry or accommodate *(referred to as the current rating)* to ensure safety of operations.

4.4.1.3 The current rating of a circuit shall not be less than the current demand (or maximum demand) of the circuit.

4.4.2 Determination of current demand

4.4.2.1 Apart from indicating that current demand must be assessed, the information and values given in the Liberia LEWC for determination of current demand are intended for general guidance only as it is impossible to specify the appropriate allowances for diversity for every type of electrical installation.

Non-simultaneous or cyclic loads

4.4.2.2 For a circuit having non-simultaneous or cyclic loads such that only one of these loads can be in use at any one time, the greatest *(or largest)* of these loads shall be used in calculating the current demand of the circuit.

Final circuits

4.4.2.3 For standard final circuits designed in accordance with Code 4.2 and Code 4.3, the current demand of the circuit concerned shall be the same as the rating of the overcurrent protective device of the circuit.

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4.4.2.4 The current demand of a final circuit other than that in clause 4.4.2.3 shall be assessed by summating the assumed current demands of current-using equipment connected or intended to be connected as follows:

(a) Each socket outlet in a radial final circuit shall be assumed to demand its current rating.

(b) Lighting outlets shall be assumed to demand the connected load with 60W per lamp holder for incandescent lamps or the actual wattage of the lamp to be installed, whichever is the greater, except if the design of the luminaire associated with the lamp holder only permits lamps of less than 60W to be inserted in any lamp holder, in which case, the connected load of that lamp holder is the wattage of the highest rated lamp that may be accommodated.

(c) Fluorescent and other discharge lamps (e.g., low- or high-pressure sodium lamp, metal halide lamps, etc.) shall be assumed to have a demand in volt-amperes of the rated lamp wattage multiplied by a factor, which takes into account control gear losses and harmonic currents; in the absence of more precise information from manufacturer, a factor of not less than 1.8 could be adopted.

(d) Electric clock, shaver socket outlet, bell transformer, and current-using equipment of a rating not greater than 5VA may be neglected.

(e) All other fixed equipment shall be assumed to demand the rated or normal current.

Supplies feeding multiple final circuits

4.4.2.5 The condition that only a few sockets or load points on the circuit will be in use at the same time, and that the loads they feed will be small is referred to as diversity.

4.4.2.6 Allowance shall be made for reasonable diversity to reduce the number of circuits and their rating with a consequent financial saving, but without reducing the effectiveness of the installation.

4.4.2.7 Diversity shall be properly assessed considering detailed knowledge of a number of factors including but not limited to the following:

(a) the type of installation,

(b) the industrial process concerned where this applies,

(c) the habits and practices of the users, and

(d) possible future increase in load

4.4.2.8 The current demand of a circuit supplying a number of final circuits may be determined by applying the allowances for diversity given in Table 4-3 to the total current demand of all the equipment connected to the circuit and not by summating the current demands of the individual final circuits obtained according to clause 4.4.2.4.

4.4.2.9 The following shall be noted in the use of Table 4-3:

(a) Table 4-3 applies only to LV installations having a current demand not exceeding 400A in each phase.

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(b) For installations having a current demand exceeding 400A per phase, the allowances for diversity must be assessed by an electrical professional of appropriate grade.
(c) The allowances in Table 4-3 are expressed either as a percentage of the current demand or rated full load current of equipment *(X, Y or Z as provided on top of the Table).*
(d) Table 4-3 does not apply to installations in factories and industrial undertakings; allowances for diversity of such installations will depend on the type of plant and machinery and their operational requirements.

Table 4-3**: Allowances for Diversity**

Note the following abbreviations:
X is the full load current of the largest appliance or circuit
Y is the full load current of the second largest appliance or circuit
Z is the full load current of the remaining appliances or circuits

Item No.	**Purpose of Circuit or Switchgear to which Diversity applies**	**Type of Premises**		
		Residential Installations	**Small Shops/ Offices / Business Premises**	**Small Hotels/ Boarding Houses etc**
1.	Lighting	66% of total current demand	90% of total current demand	75% of total current demand
2.	Heating & Power	100% up to 10 A + 50% of the balance demand	100(X+0.75(Y+Z)) %	100(X+.8Y+.6Z) %
3	Cookers	10A + 30% of full load balance + 5A for socket	100(X+.8Y+.6Z) %	100(X+.8Y+.6Z) %
4	Motors (excluding lifts)		100(X+.8Y+.6Z) %	100(X+.5(Y+Z)) %
5.	Instantaneous water heaters	100(X+Y+.25Z) %	100(X+Y+.25Z) %	100(X+Y+.25Z) %
6	Thermostatic water heaters	100% (No diversity allowable)		
7.	Thermal storage heating			
8.	Water pumps	100% full load of the largest pump motor and 25% of the remaining motors i.e., 100(X+.25Z) %		
9	Air conditioner	100(X+.4Z) %	100% of current demand of largest point of utilization+ 75% of current demand of every other point of utilization	
10.	Standard Circuits	100(X+.4(Y+Z)) %	100(X+.5(Y+Z)) %	100(X+.5(Y+Z)) %
11.	Sockets & stationary equipment	100(X+.4(Y+Z)) %	100(X+.75(Y+Z)) %	100(X+.75Y+.4Z) %

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4.5 Segregating Circuits

4.5.1 General

4.5.1.1 Care shall be taken to ensure that circuits are not affected by electrical interference, both electrostatic (due to electric fields) or electro-magnetic (due to electro-magnetic fields).

4.5.2 Mutual detrimental influence

4.5.2.1 Electrical equipment shall be selected and erected to avoid any harmful influence between the electrical installation and any non-electrical installations envisaged.

4.5.2.2 Where a wiring installation requires different types of current or at different voltages grouped in a common assembly all the equipment belonging to any one type of current or any one voltage shall be effectively segregated wherever necessary to avoid mutual detrimental influence by using effective methods including any or a combination of the following methods:

(a) every cable involved is insulated for the highest voltage present;
(b) each conductor in a multicore cable is insulated for the highest voltage present;
(c) conductors of the different voltage bands are separated by an earthed metal screen;
(d) installation in separate compartments of a trunking or ducting system;
(e) installation on a tray with a partition providing separation; or
(f) a separate conduit or ducting system is provided for each band.

4.5.2.3 Where it will be necessary for circuit outlets for both voltage bands to share a common box or switch plate or block, the connections of circuits of the differing voltage bands shall be segregated by a partition, which must be earthed if made of metal construction.

4.5.3 Electromagnetic compatibility

4.5.3.1 The immunity levels of equipment shall be chosen taking into account:

(a) the electromagnetic influences that can occur when connected, and erected as for normal use; and
(b) the intended level of continuity of service necessary for the application.

4.5.3.2 Equipment shall be chosen with sufficiently low emission levels so that it cannot cause unacceptable electromagnetic interference with other electrical equipment by electrical conduction or propagation in the air. If necessary, measures shall be taken to minimize the effects of the emission.

4.5.4 Lift and hoist shaft circuits

4.5.4.1 A lift shaft shall not be used for running cables except for circuits which are part of the lift or hoist installation including the:

(a) power cables fixed in the shaft to feed the motor(s), or
(b) control cables which feed call buttons, position indicators, etc.

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4.5.4.1 Trailing cables may be used to feed call buttons, position indicators, lighting and telephones in the lift itself.

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CODE 5: ISOLATION & SWITCHING REQUIREMENTS

5.1 Provision of Isolation and Switching

5.1.1 General

5.1.1.1 Every circuit or group of circuits connected to an installation must be provided with:

(a) a means of interrupting the supply on load through provision of a main switch or circuit breaker; and

(b) a means of isolation to cut off all voltages.

5.1.1.2 Where a single device is provided to perform the two functions stated in clause 5.1.1.1, the main switch or circuit breaker shall:

(a) interrupt all live conductors (i.e., phase and neutral conductors); and

(b) be capable of cutting off the full load current of the installation from supply.

5.1.1.3 For all installations, load or circuit isolations shall only be carried out in the live and non-earthed neutral conductors.

5.1.1.4 Subject to clause 3.1.4.12 and for the purposes of performing certain tests such as earth testing, an isolating link of the same current-carrying capacity shall be provided which shall remain permanently connected except and only when all the live and neutral connections have been disconnected from the supply.

5.1.1.5 Where a standby generator is installed, electrically and mechanically interlocked 4-pole changeover devices shall be used for interconnection between the normal and standby sources of supply to ensure that any neutral unbalance and fault current returns to the correct source of supply.

5.1.2 Appliance, equipment or luminaire

5.1.2.1 An appliance, equipment or luminaire, other than that connected by means of a plug and socket outlet shall be provided with a means of interrupting the supply on load.

5.1.2.2 An effective additional local means for isolation of the circuit from supply shall be provided for every self-contained luminaire, or circuit supplying luminaires of an electric discharge lighting installation operating normally at an open-circuit voltage exceeding LV.

5.1.3 Electric motors

5.1.3.1 Electric motors, except exhaust fans having rated power not exceeding 50W and servomotors, shall be provided with:

(a) means of isolation suitably placed and so connected that all voltages may be cut off from the motor and all apparatus including any automatic circuit breaker used therewith. If this means of isolation is remote from a motor, an additional means of isolation adjacent to the motor shall be installed or, alternatively, a provision shall be made so that the means of isolation can

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be secured against inadvertent operation;

(b) means for starting and stopping, suitably placed for ready operation; and

(c) means to prevent automatic restarting after a stoppage due to drop in voltage or supply failure, where unexpected restarting of the motor may pose danger.

5.1.4 22kV main switch

5.1.4.1 A 22kV main switch (i.e. the circuit breaker) that is used to receive supply directly from a service provider's transformer, shall:

(a) be rated for use at 22kV and a fault level of 25kA rms for 3 seconds; and

(b) have a lightning impulse withstand voltage that is not less than 125kV peak.

5.1.4.2 Where an 11kV main switch (i.e. the circuit breaker) is used to receive supply directly from a service provider's transformer, it shall:

(a) be rated for use at 11kV and a fault level of 18.4kA rms for 3 seconds; and

(b) have a lightning impulse withstand voltage that is not less than 75kV peak.

5.1.4.3 The main breaker (of the switch),

(a) shall not exceed the approved rated loading for fault making and breaking, that is agreed with the service provider; and

(b) must be fitted with an earthing switch to earth the incoming cable.

5.1.4.4 Interlock facilities shall be provided between the circuit breaker, the earthing switch and the isolator, and a safety shutter at the switchgear spouts.

5.1.5 Direct current (DC) system

5.1.5.1 All conductors of a DC circuit, except for a conductor connected either to earth or to a protective earthing conductor, shall be capable of being isolated by a device for isolation.

5.2 Characteristics and Types of Isolation and Switching Devices

5.2.1 General

5.2.1.1 The arrangement and characteristics of isolating and switching devices shall satisfy all the requirements under this Code 5.2, where a common device is used to perform one or more of the following:

(a) means of isolation;

(b) means of switching off for mechanical maintenance;

(c) means of emergency switching; and

(d) means of functional switching.

5.2.2 Isolating devices

5.2.2.1 An isolating device shall be capable of:

(a) opening and closing all live conductors (i.e., phase and neutral conductors) of the circuit under no-load condition;

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(b) carrying the normal circuit current; and
(c) carrying, for a specified time, abnormal currents which may occur during an overcurrent condition (such as overload or short-circuit).

5.2.2.2 The position of the contacts or other means of an isolation device shall be either externally visible or clearly and reliably indicated.

5.2.2.3 An isolating device shall be designed and/or installed efficiently to prevent unintentional or inadvertent closure.

5.2.2.4 Where the location of the isolator is remote from the circuit protected, it shall be provided, where necessary, with means such as padlock system to prevent reclosure when not required.

5.2.2.5 Devices with the characteristics specified under this code 5.2.2 that are considered acceptable to function as an isolating device include:
(a) isolators (disconnectors),
(b) fuse switches and switch-fuses,
(c) links, including fuse-links and fuse cut-outs,
(d) plugs and socket outlets,
(e) cable couplers,
(f) circuit breakers, including:
(i) miniature circuit breakers (MCB);
(ii) molded case circuit breakers (MCCB);
(iii) residual current operated circuit breaker with integral overcurrent protection (RCBO); and
(iv) residual current circuit breakers without integral overcurrent protection (RCCB).

5.2.3 Devices for switching off for mechanical maintenance

5.2.3.1 Means of switching off for mechanical maintenance shall be provided where mechanical maintenance may involve risk of burns or injury from mechanical movement.

5.2.3.2 A device used for switching off for mechanical maintenance shall:
(a) require manual operation;
(b) have visible or clearly and reliably indicated open and closed positions of the contacts;
(c) be designed and installed in such a way to prevent inadvertent or unintentional switching on;
(d) be capable of cutting off the full load current of the relevant part of the installation; and
(e) be readily accessible for operation.

5.2.3.3 Based on the characteristics described in clause 5.2.3.2, devices that are acceptable for use as means for switching off for mechanical maintenance, include:

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(a) switches,
(b) circuit breakers,
(c) control switches and operating contactors, and
(d) plugs and socket outlets.

5.2.4 Devices for emergency switching

5.2.4.1 Means shall be provided for emergency switching of any part of an installation or cutting off appropriate supply circuit, where it may be necessary, to control the supply to remove or contain an unexpected or apparent danger.

5.2.4.2 A means for emergency switching shall be arranged to act directly as may be possible on the appropriate supply conductors such that one single action only must interrupt the appropriate supply.

5.2.4.3 Interrupting the supply for the purpose of emergency switching shall be capable of cutting off the full load current of the relevant part(s) of the installation.

5.2.4.4 The means of operation shall be capable of latching or being restrained in the 'off' or 'stop' position, unless both the means of operation for emergency switching and for re-energizing are under the control of the same person.

5.2.4.5 The means of operating a device for emergency switching, such as a handle or push-button, shall be:
(a) clearly and durably marked;
(b) preferably colored red; and
(c) located:
(i) in a readily accessible position where danger might occur and,
(ii) where appropriate, at any additional remote position from which that danger can be removed.

5.2.4.6 Based on the characteristics described in clause 5.2.4.5, the following devices are acceptable as emergency switches:
(a) a switch in the main circuit (e.g., fireman's switch for HV discharge lighting installation), or
(b) a push button or similar device installed in a control or auxiliary circuit (e.g. emergency stop for machinery).

5.2.4.7 A plug and socket outlet or similar device shall not be selected as a device for emergency switching.

5.2.4.8 A fireman's emergency switch shall be:
(a) colored red and have fixed on (or near) it a permanent durable nameplate marked with the words " FIREMAN'S SWITCH"; and
(b) provided with a device to prevent the switch being inadvertently returned to the 'ON' position to re-energize the relevant part of the installation.

5.2.4.9 Where an electrically powered equipment is within the scope of IEC 60204, the requirements for emergency switching of that standard shall apply.

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5.2.5 Functional switching & control devices

5.2.5.1 A functional switching device shall be provided for each part of a circuit which may require to be controlled independently of other parts of the installation.

5.2.5.2 Functional switching devices need not necessarily control all live conductors of a circuit; but a switching device shall not be placed solely in the neutral conductor.

5.2.5.3 All current-using equipment requiring control shall be controlled by an appropriate functional switching device. A single functional switching device may control several items of equipment intended to operate simultaneously.

5.2.5.4 Functional switching devices enabling the change-over of supply from alternative sources shall switch all live conductors and shall not be capable of connecting the sources in parallel unless the installation is specifically designed for this condition or purpose.

5.2.5.5 Where alternative sources of supply exist, no provision shall be made for isolation of the PEN (Protective Earth Neutral) or protective conductors, unless the design specifically requires such isolation.

5.2.5.6 Control (or auxiliary) circuits shall be designed, arranged and protected to limit dangers resulting from a fault between the control circuit and other conductive parts liable to cause malfunction (e.g. inadvertent operation) of the controlled equipment.

5.2.5.7 Functional switching devices shall be suitable for the most onerous duty intended.

5.2.5.8 Functional switching devices such as semiconductor switching devices may control the current without necessarily opening the corresponding poles of the supply.

5.2.5.9 Semiconductors themselves are functional switches operating very rapidly to control the circuit voltage, but they must NOT be used as isolators because when not conducting (in the OFF position) they still allow a very small leakage current to flow and have not totally isolated the circuit they control.

5.2.5.10 A plug and socket outlet of rating not exceeding 15A may be used for functional switching, except for use with DC supply where this provision is prohibited.

5.2.5.11 Off-load isolators (disconnectors), fuses and links shall not be used for functional switching.

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CODE 6: PROTECTIVE MEASURES FOR SAFETY-*(Earth leakage and Earth fault currents)*

6.1 Protection Against Electric Shock

6.1.1 General requirements

6.1.1.1 Every installation, either as a whole or in its several parts, shall comply with protective measures and requirements prescribed in this Code 6 of the LEWC.

6.1.1.2 The order in which the protective measures are listed shall not be taken to imply the relative importance of the different measures.

6.1.1.3 For an installation or part thereof where there exists increased risk of electric shock by reduction in body resistance or by contact with earth potential, the relevant requirements of this LEWC shall apply in addition to the requirements contained in other parts of the LEWC.

6.1.1.4 The effects of an electric shock vary considerably depending on the following factors:

(a) the value of the shock current imposed on the nervous system;

(b) the path taken by the shock current through the body; and

(c) the duration for which the shock current flows.

6.1.1.5 Protection against electric shock shall be provided by application of:

(a) measures adequate for protection against both direct contact and indirect contact, or

(b) a combination of appropriate measures for protection specifically against:

(i) direct contact, or

(ii) indirect contact.

6.2 Protection Against Both Direct and Indirect Contact

6.2.1 General

6.2.1.1 One of the following basic methods shall be used to provide for protection against both direct contact and indirect contact:

(a) protection by SELV; and

(b) protection by limitation of discharge of energy.

6.2.2 Protection by SELV

Sources for SELV

6.2.2.1 The source of supply for an SELV protection scheme shall have a nominal voltage not exceeding extra-low voltage and shall be provided from one of the following:

(a) a safety isolating transformer complying with appropriate Liberia Standard in which there shall be no connection between the output winding and the body or the protective earthing circuit, if any; or

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(b) a source of current such as a motor-generator with windings providing electrical separation equivalent to that of the safety isolating transformer specified in (a) above; or
(c) an electrochemical source (e.g., a battery) or another source independent of a higher voltage circuit (e.g., an engine driven generator); or
(d) certain electronic devices complying with appropriate standards where measures have been taken so that even in the case of an internal fault the voltage at the output terminals cannot exceed extra-low voltage levels.

6.2.2.2 Despite clause 6.2.2.1(d), a higher voltage at the output terminals is permitted, if the voltage at the output terminals is immediately reduced to the values within the extra-low voltage range when measured with a voltmeter having an internal resistance of at least 3000 ohms.

6.2.2.3 A system supplied from a higher voltage system by other equipment which does not provide the necessary electrical separation, such as an autotransformer, potentiometer, semiconductor device etc., shall be deemed not suitable for use as a SELV system.

SELV circuit requirements

6.2.2.4 The live part of a SELV system shall:
(a) be electrically separated from any other circuits that carry higher voltages. Except for cables the electrical separation shall be not less than that between the input and output of a safety isolating transformer.
(b) not be connected to Earth or to a live part or a protective conductor forming part of another circuit or system.

6.2.2.5 No live part or exposed-conductive-part of a SELV system shall be connected to any of the following:

(a) an exposed-conductive part of another system;
(b) an extraneous-conductive part, except that where electrical equipment is inherently required to be connected to an extraneous-conductive part, measures shall be incorporated so that the parts cannot attain a voltage exceeding extra-low voltage.

6.2.2.6 Where the nominal voltage of a SELV system does not exceeds 25 V AC rms or 60V ripple-free DC, protection against direct contact shall be deemed unnecessary, <u>otherwise</u> protection against contact shall be provided by one or more of the following:

(a) a barrier or an enclosure affording at least the degree of protection IP2X or IPXXB; or
(b) insulation capable of withstanding a type-test voltage of 500 V AC rms for 60 seconds.

6.2.2.7 A socket outlet in a SELV system shall require the use of a plug which is dimensionally not compatible with those used for any other system in use in the same premises and shall have no protective conductor contact.

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6.2.2.8 A luminaire-supporting coupler equipped with a protective conductor contact shall not be installed in a SELV system.

SELV protection applications

6.2.2.9 Subject to specific applications cited in Code 9, SELV protection is generally applicable for some appliances, installations and locations of increased shock risk particularly in situations where:

(a) it is the only permitted measure against electric shock;
(b) a reduction in the nominal voltage is prescribed; and
(c) protection against direct contact has to be provided irrespective of the nominal voltage (as prescribed in Clause 6.2.2.7).

Other extra-low voltage systems including functional extra-low voltage

6.2.2.10 Functional extra-low voltage alone shall not be used as a protective measure.

6.2.2.11 Where, for functional reasons, extra-low voltage is used but not all the requirements relating to SELV are fulfilled, other measures shall be applied to provide protection against direct and indirect contact.

6.2.3 Protection by limitation of discharge of energy

6.2.3.1 For equipment complying with the appropriate Liberia Standard, protection against both direct and indirect contact shall be deemed to be provided when the equipment incorporates means of limiting the current which can pass through the body of a person or livestock to a value lower than that likely to cause danger.

6.2.3.2 A circuit relying on the protective measure described in clause 6.2.3.1 shall be separated from any other circuit in a manner equivalent to that specified in clause 6.2.2.4 for a SELV circuit.

Application of Limitation of discharge of energy protection

6.2.3.3 Limitation of discharge of energy protection measures shall be applied only to an individual item of current-using equipment complying with an appropriate British Standard or IEC standard (*IEC 61140: Protection against electric shock – Common aspects for installations and equipment),* where the equipment incorporates a means of limiting to a safe value the current that can flow from the equipment through the body of a person or livestock.

6.2.3.4 Application of this protective measure may be extended to a part of an installation derived from such items of equipment (such as electric fences supplied from electric fence controllers), where the Liberia Standard concerned provides specifically for this.

6.3 Protection Against Direct Contact

6.3.1 General

6.3.1.1 The methods of preventing direct contact generally seek to ensure that people cannot touch live conductors and shall include any of the following methods:

(a) insulation of live parts, considered to be the standard method;

(b) provision of barriers, or enclosures to prevent touching (IP2X, IP4X) or other protection, as appropriate from Table 6-1;
(c) provision of obstacles to prevent touching;
(d) placing out of reach or the provision of obstacles to prevent people from reaching live parts; and
(e) provision of residual current devices (RCDs) as supplementary protection where contact is from a live part to an earthed part.

Table 6-1: Numbers in the IP System [IPXX]

First No.	Mechanical protection against:	Second No.	Water protection against:
0	Not Protected	**0**	Not protected
1	Solid objects exceeding 50mm	**1**	Dripping water
2	Solid objects exceeding 12mm	**2**	Dripping water when tilted up to 15
3	Solid objects exceeding 2.5mm	**3**	Spraying water
4	Solid objects exceeding 1.0mm	**4**	Splashing water
5	Dust protected	**5**	Water jets
6	Dust tight	**6**	Heavy seas
7		**7**	Effects of immersion
8		**8**	Submersion

6.3.2 Protection by insulation of live parts

6.3.2.1 A live part shall be completely covered with insulation that can only be removed by destruction and which is capable of durably withstanding the electrical, mechanical, thermal and chemical stresses to which it may be subjected in service.

6.3.2.2 Protection by insulation of live parts is generally considered to be the standard method that relates to basic insulation and applicable for protection against direct contact, in conjunction with a measure for protection against indirect contact.

6.3.3 Protection by barriers or enclosures

6.3.3.1 Live parts shall be inside enclosures or behind barriers providing at least the degree of protection IP2X or IPXXB.

6.3.3.2 Despite clause 6.3.3.1, where an opening larger than that permitted for IP2X or IPXXB is necessary to allow for the replacement of parts or to avoid interference with the proper functioning of electrical equipment, the following two requirements shall apply:
(a) suitable precautions shall be taken to prevent persons or livestock from touching a live part unintentionally; and

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(b) it shall be established, as far as practicable, that a person is made aware that a live part can be touched through the opening and should not be touched.

6.3.3.3 The horizontal top surface of a barrier or an enclosure which is readily accessible shall provide a degree of protection of at least IP4X.

6.3.3.4 Every barrier and enclosure shall be firmly secured in place and have sufficient stability and durability to maintain the required degree of protection and appropriate separation from any live part in the known conditions of normal service.

6.3.3.5 Where it is necessary to remove a barrier, or to open an enclosure, or to remove a part of an enclosure, one or more of the following requirements shall be satisfied:

(a) the removal or opening shall be possible only by use of a key or tool;

(b) the removal or opening shall be possible only after disconnection of the supply to the live part against which the barrier or enclosure affords protection and restoration of the supply being possible only after replacement or reclosure of the barrier or enclosure; or

(c) an intermediate barrier shall be provided to prevent contact with a live part, such a barrier affording a degree of protection of at least IP2X or IPXXB and removable only by the use of a tool.

6.3.3.6 The protection by barrier or enclosure measures (in this code 6.3.3) are intended to prevent or deter any contact with a live part and are generally applicable for protection against direct contact in conjunction with a measure for protection against indirect contact.

6.3.4 Protection by obstacles

6.3.4.1 An obstacle for this type of protection measure shall –

(a) be so secured as to avoid unintentional removal but may be removable without using a key or tool; and

(b) prevent, as appropriate, either of the following:

(i) unintentional bodily approach to a live part;

(ii) unintentional contact with a live part when operating energized equipment.

6.3.4.2 Application of protection by obstacles shall be limited to areas accessible only to:

(a) skilled persons; or

(b) to instructed persons under the direct supervision of a skilled person.

6.3.4.3 Protection by obstacles measure shall not be used for locations or installations of increased shock risk.

6.3.5 Protection by placing out of reach

6.3.5.1 A bare live part other than an overhead line shall not be within arm's reach or 2.5m of any of the following:

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(a) an exposed conductive part
(b) an extraneous conductive part
(c) a bare live part of any other circuit.

6.3.5.2 If access to a live equipment is restricted in the horizontal plane by an obstacle (e.g., handrail, mesh, screen), the extent of arm's reach from a normally occupied position shall be measured from that obstacle.

6.3.5.3 In each place where any bulky or long conducting object is normally handled, the distances required by clauses 6.3.5.1 and 6.3.5.2 shall be increased accordingly.

6.3.6 Supplementary protection by residual current devices (RCDs)

6.3.6.1 The use of a residual current device shall be recognized as reducing the risk of electric shock where the following conditions are met:
(a) one of the protective measures specified under Code 6.3 is applied; and
(b) the RCD shall have rated residual operating characteristics as provided under code 7.1.8. An RCD shall not be used as a sole means of protection against direct contact.

6.3.6.2 A socket outlet rated at 32A or less, or a flexible cable or cord having a current-carrying capacity of 32A or less which may reasonably be connected to or expected to supply portable equipment for use outdoors shall be provided with supplementary protection to reduce the risk associated with direct contact by means of a residual current device having the characteristics specified in code 7.1.8. (Also see clause 7.3.2.10).

6.3.6.3 Where the measure is used in an installation forming part of a TT system, every socket outlet circuit shall be protected by a residual current device and shall comply with code 7.3.3.

6.4 Protection Against Indirect Contact

6.4.1 General

6.4.1.1 The methods of providing protection from shock due to indirect contact (i.e., with conductor which would normally not be live) include the following:
(a) application of earthed equipotential bonding (to ensure low resistance path between touched parts) and automatic disconnection of the supply (to guard against other faults such as overheating that may lead to fire);
(b) limitation of earth fault loop impedance (making sure that when a fault occurs and makes the parts live, it results in the supply being cut off within a safe time) – details as provided in codes 7.3.2;
(c) use of residual current device (RCD) to cut off the supply before a fatal shock can be received – details as provided in code 7.1.8;
(d) protection by Class II equipment (in which case double or reinforced insulation is used instead of protective earthing and basic insulation); and
(e) protection by electrical separation.

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6.4.2 Protection by earthed equipotential bonding and automatic disconnection of supply

6.4.2.1 This protection measure shall ensure that the voltages between any simultaneously accessible exposed and extraneous conductive parts occurring anywhere in an installation is limited to a magnitude and duration that does not pose danger.

6.4.2.2 For an installation,

(a) the main earthing terminal shall be connected to the installation's exposed and extraneous conductive parts including the following:
    (i) metallic service pipes;
    (ii) metallic conduit, trunking and ducting for enclosures of cables;
    (iii) exposed metallic structural parts of the building including switchgear & control gear assemblies; and
    (iv) the lightning protective system.

(b) each protective device, the earthing arrangement for the installation and the circuit shall be such that the protective device shall operate to clear an earth fault fast enough to avoid danger.

6.4.2.3 Conventional means of compliance with clause 6.4.2.2(b) is provided in codes 7.3.2 and 7.3.3 respectively for TN and TT earthing systems and any other effective means.

6.4.2.4 In premises with multiple installations, simultaneously accessible exposed-conductive parts shall connect to the same earthing system individually, in groups or collectively.

6.4.2.5 Aluminum or copper clad aluminum conductors shall not be used for bonding connections to water pipes which are likely to be subjected to condensation in normal use.

6.4.2.6 Main equipotential bonding conductors shall have cross-sectional areas not less than half the cross-sectional area of the earthing conductor of the installation, subject to a minimum of 6mm^2 copper equivalent, and may not have to exceed 25mm^2 copper equivalent.

6.4.2.7 For installations and locations of increased shock risk, such as those in Code 9 additional measures may be required, such as:

(a) automatic disconnection of supply by means of a residual current device having a rated residual operating current ($I_{\Delta}n$) not exceeding 30mA;
(b) supplementary equipotential bonding; and
(c) reduction of maximum fault clearance time.

6.4.3 Protection by automatic disconnection and reduced low voltage systems

6.4.3.1 Automatic disconnection using a residual current device shall not be applied to a circuit incorporating a PEN conductor.

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6.4.3.2 In every installation which provides for protection against indirect contact by automatic disconnection of supply, a circuit protective conductor shall be run to and terminated at each point in the wiring and at each accessory except a lamp holder having no exposed-conductive parts and suspended from such a point.

6.4.3.3 The characteristics of this protection measure including the coordination of protective devices for automatic disconnection and the relevant impedances of the circuits shall depend on the type of earthing system used as follows to limit the magnitude and duration of resulting voltage between exposed accessible conductive parts:

(a) TN earthing system or;
(b) TT earthing system.

6.4.3.4 Where the conditions for automatic disconnection of code 7.3.2 (TN systems) and code 7.3.3 (TT systems) cannot be fulfilled by using overcurrent protective devices, then either:

(a) local supplementary equipotential bonding shall be applied, but the use of bonding does not remove the need to disconnect the supply due to other reasons, such as overheating, or
(b) protection shall be provided by means of residual current device.

6.4.4 Supplementary equipotential bonding

6.4.4.1 Where local supplementary equipotential bonding is necessary for compliance with the main equipotential zone requirements, bonding connections shall be made to metal parts where those parts are:

(a) extraneous conductive parts, and
(b) simultaneously accessible (i.e., within 2m separation) with exposed conductive parts or other extraneous conductive parts, and
(c) not electrically connected to the main equipotential bonding by permanent and reliable metal-to-metal joints of negligible impedance.

6.4.4.2 Subject to clause 6.4.4.1 the recommended resistance (R) of the supplementary bonding conductor between simultaneously accessible exposed-conductive parts and extraneous-conductive parts shall fulfill the following condition:

$$R \leq {}^{50}/_{Ia}$$

where: I_a is the operating current of the protective device which, for –

(i) a residual current device, is the rated residual operating current, $I_{\Delta n}$; and
(ii) an overcurrent device, it is the minimum current which disconnects the circuit within 5s.

6.4.4.3 Measurement of the insulation resistance between the conductive part and the main earthing terminal shall be taken to determine whether conductive parts such as metallic bathroom accessories, metallic windows or metallic door handles etc. are extraneous conductive parts for the necessary action to be taken.

6.4.4.4 The minimum cross-sectional area of a supplementary bonding conductor shall comply with Table 7-3, subject to the following conditions:

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(a) The bonding conductor connecting two exposed conductive parts shall have a cross-sectional area not less than that of the smaller protective conductor connected to the exposed conductive parts.
(b) The bonding conductor connecting exposed conductive parts to extraneous conductive parts shall have a cross-sectional area not less than half that of the protective conductor connected to the exposed conductive part.
(c) The bonding conductor connecting two extraneous conductive parts, where one of the extraneous parts is connected to an exposed conductive part, shall have a cross-sectional area not less than half that of the protective conductor connected to the exposed conductive part.

6.4.5 Protection by use of Class II equipment or by equivalent insulation

6.4.5.1 Protection by use of Class II equipment shall be provided by one or more of the following:
(a) electrical equipment of the following types, type-tested and marked to the relevant standards:
(i) having double or reinforced insulation (Class II equipment)
(ii) low voltage switchgear and control gear assemblies having total insulation (see BS EN 60439);
(b) supplementary insulation applied to electrical equipment having basic insulation only, as a process in the erection of an electrical installation, providing a degree of safety equivalent to that of electrical equipment according to item (a) above and complying with the subsequent clauses under this code 6.4.5;
(c) reinforced insulation applied to uninsulated live parts, as a process in the erection of an electrical installation, providing a degree of safety equivalent to electrical equipment according to item (a) above and complying with the subsequent clauses under this code 6.4.5, and such insulation being recognized only where constructional features prevent the application of double insulation.

6.4.5.2 The enclosure provided for this protection measure shall:
(a) not adversely affect the operation of the equipment protected; and
(b) be capable of resisting mechanical, electrical and thermal stresses likely to be encountered.

6.4.5.3 When the electrical equipment is ready for operation, all conductive parts separated from live parts only by basic insulation shall be contained in an insulating enclosure affording at least the degree of protection IP2X or IPXXB.

6.4.5.4 Where the insulating enclosure has to be pierced by conductive parts (e.g. for operating handles of built-in equipment, and for screws) protection against indirect contact shall not be impaired.

6.4.5.5 Where a lid or door of an insulating enclosure can be opened without the use of a tool or key, every conductive part which is accessible upon opening the lid or door shall be behind an insulating barrier that provides a degree of protection of

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at least IP2X or IPXXB and removable only by use of a tool to prevent a person from coming into contact with those parts.

6.4.5.6 No conductive part enclosed in an insulating enclosure shall be connected to a protective conductor.

6.4.6 Protection by electrical separation

6.4.6.1 Safety from shock may be ensured by separating a system completely from others so that there is no complete circuit through which shock current could flow by ensuring that earth impedances are very high.

6.4.6.2 The mobile or fixed source of supply to an electrically separated circuit whose voltage shall not exceed 500V shall be either:

(a) an isolating transformer complying with BS 3535; or

(b) a current source such as a battery or motor-generator set providing a degree of safety equivalent to an isolating transformer specified in (a).

6.4.6.3 An installed separated circuit shall:

(a) have no live part connected to another circuit or to earth;

(b) not use flexible cable or cord liable to mechanical damage; and

(c) have all its cables run separately from all other circuits.

6.4.6.4 For a circuit supplying a single item of equipment, no exposed conductive part of the separated circuit shall be connected either to the protective conductor of the source or to any exposed conductive part of any other circuit.

6.5 Protection Against Thermal Effects

6.5.1 General

6.5.1.1 Persons, equipment, and materials adjacent to electrical equipment shall be protected from harmful thermal effects such as:

(a) fire;

(b) degradation of materials;

(c) risk of burns; or

(d) limiting the safe functioning of installed equipment.

6.5.2 Protection against fire and harmful thermal effects

6.5.2.1 In addition to protection against electric shock, protection against fire is another main target of a proper design of electrical installation.

6.5.2.2 Apart from the minimum requirement of ensuring coordination between overcurrent protective device and conductor permanent and short-time withstand, additional protective measures recommended in this code 6.5.2 may be taken to reduce the risk of fire due to electrical installation.

6.5.2.3 Electrical equipment shall not present a fire hazard or harmful thermal effects to material adjacent or that may be in proximity to such equipment and any relevant installation instruction of such equipment shall be observed.

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6.5.2.4 Where an installed fixed electrical equipment during normal operation is likely to produce a surface temperature sufficient to cause a risk of fire or harmful effects to adjacent materials or other equipment, one or more of the following installation methods shall be adopted:

(a) mounting on a low thermal conductance support or within an enclosure that can withstand any such temperatures generated, without risk of fire or harmful effect;
(b) screening by material which can withstand without risk of fire or harmful effect the heat emitted by the electrical equipment; and
(c) mounting to allow for safe dissipation of heat and at sufficient distance from adjacent material.

6.5.2.5 Where an arc or high temperature particles may be emitted by fixed equipment one or more of the following installation methods shall be adopted:

(a) Total enclosure in arc-resistant material that shall be non-ignitable and of adequate thickness to provide mechanical stability.
(b) Screening by arc-resistant material.
(c) Mounting to allow safe extinction of the emissions at a sufficient distance.
(d) Every termination of live conductors or joints shall be contained within an enclosure selected in accordance with the appropriate Liberia Standards.
(e) Where electrical equipment at a single location contains, in total, flammable liquid more than 25 liters, adequate precautions shall be taken to prevent the spread of burning liquid, flame and the products of combustion.
(f) Fixed equipment causing a concentration of heat shall be located at a sufficient distance from any other fixed object to prevent dangerous temperatures affecting the fixed object.
(g) Materials used for the construction of enclosures shall be heat and fire resistant according to the appropriate product standard. Where no product standard exists, the materials of an enclosure constructed during erection shall withstand the highest temperature likely to be produced by the electrical equipment in normal use.

6.5.2.6 For main circuits and distribution circuits, more sensitive earth fault detection than the one necessary for protection against electric shock is recommended.

6.5.2.7 In addition to RCD, arc-fault detection device is recommended for terminal circuits where:

(a) mechanical withstand of conductor is lower;
(b) the number of connections is higher; and
(c) portable equipment can be supplied.

6.5.3 Protection against burns and overheating

6.5.3.1 An accessible part of a fixed electrical equipment within arm's reach shall not attain a temperature more than the appropriate limit stated in Table 6-2 unless there is a specified limiting temperature.

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6.5.3.2 Any part of the fixed installation likely to attain a temperature exceeding the appropriate limit stated in clause 6.5.3.1 under normal load conditions, even for a short period, shall be guarded to prevent accidental contact.

Table 6-2: Temperature limit under normal load conditions for an accessible part of equipment within arm's reach

Part	Material of accessible surface	Maximum Temperature (°C)
1. A hand-held means of operation	Metallic Non-metal	55 65
2. A part intended to be touched but not hand-held	Metallic Non-metal	70 80
3. A part that needs not be touched for normal operation	Metallic Non-metal	80 90

6.5.4 Protection against overheating

Forced air heating systems

6.5.4.1 Forced air heating systems shall be such that their electric heating elements, other than those of central-storage heaters, cannot be activated until the prescribed air flow has been established and are deactivated when the air flow is reduced or stopped.

6.5.4.2 In addition to clause 6.5.4.1, the systems shall have two temperature limiting devices independent of each other which prevent permissible temperatures from being exceeded.

Appliances producing hot water or steam

6.5.4.3 An electric appliance producing hot water or steam shall be protected by design or method of erection against overheating in all service conditions.

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CODE 7: PROTECTIVE DEVICES & ARRANGEMENTS

7.1 Protection Against Overcurrent

7.1.1 General requirements

7.1.1.1 Every circuit must be protected by one or more devices for automatic interruption of the supply in the event of overcurrent resulting from:
(a) overload, or
(b) fault.

7.1.1.2 The following devices are acceptable as protective devices against overcurrent:
(a) Miniature Circuit Breakers (MCB);
(b) Molded Case Circuit Breakers (MCCB);
(c) High Breaking Capacity (HBC) Fuses;
(d) Semi-enclosed Fuses; and
(e) Circuit Breakers incorporating overcurrent release, or in conjunction with fuse.

7.1.1.3 Devices that provide protection against both overload current and fault current shall satisfy both the requirements of overload and fault current protective devices.

7.1.1.4 The characteristics of devices for overload protection shall be coordinated such that the energy let through by the fault current protective device does not exceed that which the overload protective device can withstand without damage.

7.1.1.5 Fuse switch, Switch-fuse, Residual Current Operated Circuit Breakers with Integral Overcurrent Protection (RCBO), Miniature Circuit Breakers (MCB) and Molded Case Circuit Breakers (MCCB) shall be equipped with lockable function such that these devices can be locked off and only be able to be unlocked by the use of keys or tools used to lock off these devices. These keys or tools shall be under the control of the responsible person.

7.1.2 Protection against overload

7.1.2.1 All circuits shall be equipped with a device to prevent persistent flow of overload current in the circuit conductor for long durations to provide protection against temperature rise detrimental to insulation, joints, terminations, or surroundings of the conductors.

7.1.2.2 The characteristics of each protective device shall satisfy the following conditions:
(a) The nominal current or current setting of the devices (I_n) shall exceed the design current (I_z) of the circuit [$I_n \geq I_z$];
(b) The nominal current or current setting of the devices shall NOT exceed the lowest of the current-carrying capacities (I_b) of any of the conductors in the circuit [$I_b \geq I_n$];
(c) The current causing effective operation (I_{oc}) of the devices shall not exceed 1.45 times the lowest of the current-carrying capacities of any of the conductors of the circuit [$I_{oc} \leq 1.45 \times I_b$].

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7.1.2.3 If the protective device is a fuse to BS88 Part 2 or Part 6 or BS1361 or a circuit breaker to IEC 60898 or equivalent satisfying requirement in clause 7.1.2.2(b), it is also considered to have satisfied the requirement in clause 7.1.2.2(c).

7.1.2.4 If the protective device is a semi-enclosed fuse to BS3036, compliance with requirement in clause 7.1.2.2(c) is satisfied if its nominal current (I_n) does not exceed 0.725 times the current-carrying capacity (I_b) of the lowest rated conductor in the circuit protected – [$I_n \leq 0.725 I_b$]

7.1.2.5 When the same protective device protects conductors in parallel, other than that of a ring circuit, the value for 'the lowest of the current-carrying capacities' (I_b) mentioned in clause 7.1.2.2 may be taken as the sum of the current-carrying capacities of those conductors in parallel, provided that those conductors:

(a) are of the same construction, material and cross-sectional area,
(b) are approximately the same length, and
(c) have appropriate phase disposition;
(d) have no branch circuits throughout their length; and
(e) are arranged to carry substantially equal currents.

7.1.2.6 For a **Ring Circuit** with 30/32A protective device that is described in Clause 7.1.2.3,

(a) the minimum cross-sectional area of copper conductors to be used shall be as follows:

(i) Single core non-mineral insulation – 2.5mm^2
(ii) 2-core mineral insulated to BS 6207 – 1.5mm$^{2;}$ and

(b) the requirements of Clause 7.1.2.2 shall be deemed to be satisfied if $I_z \geq 0.67 I_n$.

7.1.3 Protection against fault current

7.1.3.1 A fault current protective device shall be capable of breaking a fault current (I_f) due to a short-circuit and/or earth fault condition in the conductors of each circuit before such a current causes danger due to thermal and mechanical effects produced in the conductors and connections.

7.1.3.2 The protective device shall interrupt all currents caused by a fault occurring at any point of the circuit in a time not exceeding that which brings the cable conductors to their limiting final temperature. (Note: Table 7-1 gives the limiting final temperatures for some common materials.

7.1.3.3 The current-carrying capacity of the circuit being protected shall be less than the nominal current of the protective device and the value of the prospective fault current of a circuit shall be determined by measurement and calculation.

7.1.3.4 A fault current protective device shall have a breaking capacity (**I_b**) not less than the prospective fault current (**I_f**) at the point where the device is installed [**$I_f \leq I_b$**].

7.1.3.5 Despite clause 7.1.3.4, where protective devices are connected in series, the one closer to the load could have its breaking capacity lower than the fault current (I_f) provided that operational coordination ensures that:

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(a) the device nearer the supply side has the required capacity as defined in clause 7.1.3.4; and
(b) the energy let through of these devices does not cause damage to the load side device and the conductors protected.

7.1.3.6 The clearance time, t, of a fault protective device shall be determined as follows:

$$t = {k^2 S^2}/{I_f^2}$$

where: t = time in seconds
S = cross-sectional area of the conductor in mm^2
I_f = fault current
k = cable factor, (provided by cable manufacturers) which takes into account resistivity, temperature coefficient and heat capacity of the conductor material including the initial and final operating temperatures. [*Typical k values for common conductor materials are given in Table 7-5.]*

7.1.3.7 The breaking capacities of protective devices against fault current shall be assessed for all installations. [Table 7-2 *shows the minimum breaking capacities for general guidance only.]*

Table 7-1: Limiting Final Temperatures for Common Materials

Conductor material	Insulation material	Assumed initial temperature °C	Limiting final temperature °C
Copper	70°C thermoplastic (general purpose pvc) 90°C thermoplastic (pvc) 60°C thermosetting (rubber) 85°C thermosetting (rubber) 90°C thermosetting Impregnated paper	70 90 60 85 90 80	160/140* 160/140* 200 220 250 160
Copper	Mineral — plastic covered or exposed to touch — bare and neither exposed to touch nor in contact with combustible materials	 70 (sheath) 105 (sheath)	 160 250
Aluminum	70°C thermoplastic (general purpose pvc) 90°C thermoplastic (pvc) 60°C thermosetting (rubber) 85°C thermosetting (rubber) 90°C thermosetting Impregnated paper	70 90 60 85 90 80	160/140* 160/140* 200 220 250 160
** Where two values of limiting final temperature are given the lower value relates to cables having conductors of greater than 300mm2 cross-sectional area.*			

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Table 7-2: Minimum Breaking Capacities of Overcurrent Protective Devices

Types of supply to which the protective devices are connected	Current rating of back-up fuses (if provided) to BS 88 or equivalent	Minimum three phase breaking capacities of the protective devices
(A) Supply directly taken from the transformer within the premises in which the installation is situated.	no back-up fuse fitted	40 kA
	not exceeding 160A	4.5 kA (with back-up fuses)
	exceeding 160A but not exceeding 400A	23 kA (with back-up fuses)
(B) Supply tapped from busbar rising mains (for cable rising mains, the breaking capacities may be smaller in value depending on the design)	not exceeding 160A	4.5 kA (with back-up fuses)
	exceeding 160A but not exceeding 400A	23 kA (with back-up fuses)
	no back-up fuse fitted	advice from manufacturer should be sought
(C) Supply taken from a Service Provider's service box or overhead line	not exceeding 160A	4.5 kA (with back-up fuses)
	exceeding 160A but not exceeding 400A	18 kA (with back-up fuses)
(Note: The single-phase breaking capacity should be assessed by electrical professionals of the appropriate grade)		

7.1.4 Location of protective devices

7.1.4.1 Overcurrent protective devices shall be:

(a) located at places readily accessible for maintenance; and

(b) arranged and identified so that the circuit protected may be easily recognized.

7.1.4.2 An overcurrent protective device shall be located at the point in the circuit wherever there is a change in the current-carrying capacity, subject to conditions specified in the subsequent provisions under this code 7.1.4.

7.1.4.3 For an overload current device, the device may be placed at any point along the run of those conductors provided that between the point where the value of current-carrying capacity is reduced and the position of the protective device there are no branch circuits or outlets for connection of a current-using equipment.

7.1.4.4 A fault current protective device may be placed at any point along the run of those conductors provided that between the point where the value of current-carrying capacity is reduced and the position of the protective device the conductors:

(a) do not exceed 3m in length, and

(b) are erected in such a manner as to reduce the risk of fault, fire or danger to persons to a minimum.

7.1.4.5 A fault current protective device may be placed at a point other than specified in clause 7.1.4.2 provided that the conductors between the device and the point of

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reduction in current-carrying capacity are adequately protected against fault current as provided in clause 7.1.3.5.

7.1.4.6 For general coordination purposes, the conditions stated in clause 7.1.1.4 shall apply for selection of overload current and fault current protective devices.

7.1.4.7 For a circuit incorporating a motor starter, clause 7.1.4.6 does not preclude the type of co-ordination described in IEC 60947-4-1, in respect of which the manufacturer's advice shall be sought

7.1.5 Other requirements of overcurrent protective devices

7.1.5.1 An overcurrent protective device shall be:

(a) placed in enclosure that is free from easily ignitable materials; and

(b) provided either on or adjacent to it, an indication of its intended nominal current as appropriate to the circuit it protects.

7.1.5.2 Protection fuses that are likely to be removed or replaced whilst the circuits they protect are energized, must be of a type that can be removed or replaced without danger and where necessary suitable tools for safe withdrawal of the fuses at a fuse board shall be provided.

7.1.5.3 Where a protection circuit breaker device may be operated by persons other than an electrical professional, the design or installation shall be such that it is not possible to modify the setting or the calibration of the overcurrent release without a deliberate act involving either the use of a key or tool.

7.1.5.4 Operating handles of circuit breakers shall be made accessible without opening any door or cover that gives access to live parts.

7.1.5.5 All linked circuit breakers for overcurrent protection of equipment run on polyphase supply must be purposely designed by the manufacturer to enable breaking of all related phase conductors simultaneously.

7.1.5.6 When a consumer's main switch or circuit breaker is connected directly to the service provider's distribution transformer, the overcurrent protection settings must discriminate with the service provider's HV protection settings.

7.1.6 Protection according to the nature of circuits and distribution systems

Phase Conductors

7.1.6.1 A single pole switch shall be inserted in the phase conductor of a single-phase circuit only, and for a three-phase system each phase conductor shall incorporate a protective device against overcurrent and fault current.

7.1.6.2 A fault current or overcurrent in a phase conductor must result in the disconnection of that phase conductor only, except where it is undesirable to disconnect only one phase such as a three-phase motor circuit, in which case all three phases must be disconnected.

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7.1.6.3 Despite clause 7.1.6.1, a protective device may be eliminated in a TT system with an undistributed neutral conductor, provided a differential system of protection is available to disconnect the three phases in the event of a fault in a phase.

Neutral Conductors

7.1.6.4 A protective device shall not be provided in a neutral conductor.

7.1.6.5 Despite clause 7.1.6.4, a protective device may only be inserted in a neutral conductor provided:

(a) the cross-sectional area of the neutral conductor is less than that of the phase conductors, and

(b) the operation of the protective device (such as, a linked circuit breaker, linked isolator or linked switch inserted in the neutral conductor) shall cause the disconnection of all phase conductors.

7.1.6.6 Notwithstanding clause 7.1.6.4 and subject to clause 3.1.4.12, a single-pole switch may be inserted between the earthing connection and the neutral terminals of generators running or likely to be running in parallel if it is recommended by the manufacturer and adequate precautions have been taken to avoid danger.

7.1.7 Conditions for omission of protective devices

7.1.7.1 Protective devices against overload and fault current may be omitted in the following situations:

(a) where unplanned disconnections due to operation of a protective device may cause more danger than an overload or fault such as:

(i) circuits for lifting magnets,

(ii) CT secondary circuit, or

(iii) Firefighting /extinguisher circuits;

(b) the supply source has a limiting value of current such that its maximum is less than the current-carrying capacity of the conductor (I_z); or

(c) the location is within the zone of protection of a protective device.

7.1.8 Residual current devices

Use of residual current devices

7.1.8.1 Residual current devices are installed whenever a prospective earth fault current in a circuit is insufficient to cause operation of the overcurrent protective devices within the times as specified in this code 7.1.8 and other parts of the LEWC where they are used.

7.1.8.2 Subject to code 6.3.6 and clause 7.1.8.1, protection by means of residual current device shall be provided for:

(a) a socket outlet circuit; or

(b) an electrical installation supplied from an overhead line system.

Requirements for residual current devices

7.1.8.3 Where a residual current device is installed for compliance with clause 7.1.8.2, the device shall:

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(a) have the product of the rated operating current, $I_{\Delta n}$ (in amperes) and the earth fault loop impedance, Zs (in ohms) not exceeding 50 volts i.e., Zs $I_{\Delta n}$ ≤50 volts (See also clause 7.3.2.19); and
(b) be capable of disconnecting all the phase conductor(s) of the circuit.

7.1.8.4 In addition to requirements of clause 7.1.8.3(a), an RCD for a socket outlet circuit shall have a rated residual operating current not exceeding 30 mA (I_o ≤30mA).

7.1.8.5 An RCD for fault protection may be incorporated as part of a device which also functions as an overcurrent protective device.

7.1.8.6 Subject to clause 7.1.8.5, where a RCD for fault protection is used with, but separately from, overcurrent protective devices, the RCD shall be capable of withstanding, without damage, the thermal and mechanical stresses of a fault occurring on the load side of the circuit which it protects.

7.1.8.7 Where an RCD is used, it shall:
(a) pass type test to:
(i) IEC 61008-1 (for RCCB) or
(ii) IEC 61009-1 (for RCBO) or
(iii) Equivalent (including BS 4293, 7071 & 7288);
(b) be suitable for independent toggle operation;
(c) have its tripping operation not dependent on a separate auxiliary supply;
(d) have an integral test device on the front to enable the automatic tripping operation to be tested by simulation of an earth fault condition; and
(e) be the appropriate type, considering the characteristics of the expected residual current in the circuit under protection.

7.1.8.8 When two or more RCDs are installed in series and where discrimination of their operation is necessary to prevent danger, the characteristics of the devices shall be arranged to achieve the intended discrimination. In general, a time delay must be provided in the upstream device, for example, by the use of a “Type S” (or selective) device.

7.2 Protective Conductors & Earthing Systems/Arrangements

7.2.1 General

7.2.1.1 Unless other effective precautions are taken to prevent danger, such as the use of double insulated equipment or the use of isolating transformer to IEC 61558 or equivalent:
(a) all exposed conductive parts of equipment (other than live parts) shall be connected by means of circuit protective conductors (cpc) to the main earthing terminal of the installation; and
(b) the terminal must be connected to earth electrode(s) by use of earthing conductor(s).

7.2.1.2 Exposed conductive parts shall include:
(a) metallic enclosure of current-using equipment, other than double insulated equipment;

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(b) metallic conduit, trunking and ducting for enclosure of cable(s); and
(c) metallic enclosures of current distribution equipment such as switchgear and control gear assemblies.

7.2.1.3 All metal work of electrical equipment other than current-carrying part, all metal conduit or ducts, all catenary wires, whether external or embedded in a cable and used for its support, and all close-fitting metal sheath and armor of cables, shall be earthed.

7.2.1.4 All metal sinks and cold-water pipes shall be electrically bonded to earth.

7.2.1.5 All conductors to be used for protection and every means of earthing shall be selected and installed to ensure safe operation of the associated equipment.

7.2.1.6 Where the earthing system of the installation is subdivided, each part thus divided shall comply with the requirements of this Code 7.2.

7.2.1.7 Where, in an installation there is also a lightning protection system, due account shall be taken of the requirements prescribed in code 9.2.6 and any other relevant Liberia standard such as, in the case of buildings, LS IEC 62305 or its equivalent.

7.2.1.8 Exemptions to earthing of equipment requirements under this code 7.2.1 shall be the following:
(a) Short, isolated lengths of conduit used for mechanical protection of cables having a non-metallic sheath and short isolated lengths of catenary wires used for the support of cables.
(b) Metal parts of electrical apparatus, where such parts are so enclosed and/or shrouded by insulating material that contact to human body is not possible.
(c) Fixing screws for non-metallic accessories provided that there is no appreciable risk of the screws coming into contact with live parts.
(d) Small, isolated metal parts such as bolts, rivets, nameplates, cable clips, clamps and saddles which owing to their small dimensions, or their disposition cannot be gripped or contacted by a major surface of the human body in excess of 50mm × 50mm;
(e) Lamp caps, shades, reflectors and guards supported on lamp holders or lighting fittings of non-conducting materials.
(f) Metal work, other than the current-carrying parts of the equipment of extra-low voltage circuits.
(g) Wall brackets and metal parts connected to overhead line insulators if such parts are not readily accessible.
(h) Inaccessible steel reinforcement in steel reinforced concrete poles.

7.2.2 Protective conductors

Types of Protective Conductors

7.2.2.1 Protective conductors include the following types:
(a) circuit protective conductors (cpc);
(b) main equipotential bonding conductors;
(c) supplementary bonding conductors; and
(d) earthing conductors.

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7.2.2.2 A protective conductor may consist of one or more of the following:

(a) a single-core cable or a conductor in a cable (i.e., a separate conductor or cable);

(b) an insulated or bare conductor in a common enclosure with insulated live conductors (i.e., part of the same cable containing the associated live conductors);

(c) a fixed bare or insulated conductor, rigid steel conduit, trunking or ducting;

(d) a metal covering, for example, the sheath, screen or armoring of a cable, (i.e., the metallic sheath or armor of a cable); or

(e) a metal conduit or electrically continuous support system for conductors (i.e., the metal enclosure of the wiring system).

7.2.2.3 A protective conductor of the types described in items (a) to (c) of clause 7.2.2.2 and of cross-sectional area 10 mm^2 or less, shall be made of copper material.

7.2.2.4 The metal covering including the sheath (bare or insulated), particularly the sheath of a mineral insulated cable, trunking and ducting for electrical purposes and metal conduit, may be used as a protective conductor for the associated circuit, if it satisfies the following requirements:

(a) its electrical continuity shall be assured, either by construction or by suitable connection, in such a way as to be protected against mechanical, chemical or electrochemical deterioration, and

(b) its cross-sectional area shall be at least equal to that resulting from the application of code 7.2.3.

7.2.2.5 Where the protective conductor is formed by conduit, trunking, ducting or the metal sheath and/or armor of a cable, the earthing terminal of each accessory shall be connected by a separate protective conductor to an earthing terminal incorporated in the associated box or other enclosure.

7.2.2.6 An exposed-conductive part of equipment shall not be used to form a protective conductor for other equipment.

7.2.2.7 The circuit protective conductor of every ring final circuit (other than that formed by the metal covering or enclosure of a cable) shall also be run in the form of a ring having both ends connected to the earthing terminal at the origin of the circuit.

7.2.2.8 Flexible or pliable conduit, gas or oil pipe shall not be used as a protective conductor.

7.2.2.9 A separate metal enclosure for cable shall not be used as a PEN conductor.

7.2.2.10 For every socket outlet, a separate circuit protective conductor of adequate size shall be provided connecting the earthing terminal of the socket outlet and the earthing terminal inside the enclosure accommodating the socket outlet if the cpc is formed by the enclosure.

7.2.2.11 For every length of flexible conduit, a separate circuit protective conductor of adequate size shall be provided to ensure the earth continuity of the installation between the two ends of the flexible conduit.

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7.2.2.12 Adjacent sections of a busbar trunking used as a cpc shall be connected by a protective conductor of adequate size such as copper tape or link to ensure the earth continuity between the two sections.

7.2.2.13 The requirement in clause 7.2.2.12 may be waived if it is certified by the manufacturer of the busbar trunking that the earth continuity between the adjacent sections of the busbar trunking is ensured by using the connection accessories provided by the manufacturer.

7.2.2.14 A protective conductor shall be suitably protected against mechanical and chemical deterioration and electrodynamic effects to assure preservation of electrical continuity.

7.2.3 Sizing of protective conductors

7.2.3.1 The cross-sectional area of a protective conductor shall be not less than that provided in Table 7-3, where the protective conductor is not:

(a) an integral part of a cable, or
(b) formed by conduit, ducting or trunking, or
(c) contained in an enclosure formed by a wiring system.

Table 7-3: Minimum Cross-sectional Area of Separate Protective Conductor

Installation Method	PVC Insulated (mm^2)		Bare (mm^2)	
	Copper	**Aluminum**	**Copper**	**Aluminum**
Surface wiring	2.5 (sheathed)	16	> 6	16
	4.0 (non-sheathed)	-	-	-
In Conduits or trunkings	1.0	16	1.0	16

7.2.3.2 Subject to clause 7.2.3.1, **t**he cross-sectional area of a protective conductor shall be determined in accordance with Table 7-4 provided the protective conductor is:

(a) not an equipotential or supplementary bonding conductor, and
(b) does not form part of a twin or multicore cable.

7.2.3.3 Where the application of Table 7-4 produces a non-standard size, a conductor having the nearest larger standard cross-sectional area shall be used.

7.2.3.4 For a protective conductor buried in the ground code 7.3.5 for earthing conductors also applies.

7.2.3.5 The cross-sectional area of an equipotential bonding conductor shall comply with code 7.2.4.

7.2.3.6 Where a protective conductor is common to several circuits, the cross-sectional area of the protective conductor shall be selected in accordance with clause 7.2.3.2.

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Table 7-4: Minimum cross-sectional area of protective conductor in relation to the cross-sectional area of associated phase conductor

Cross-sectional area of phase conductor S(mm^2)	Minimum cross-sectional area of the corresponding protective conductor	
	If the protective conductor is of the same material as the phase conductor(mm^2)	If the protective conductor is not the same material as the phase conductor (mm^2)
S ≤ 16	S	$\frac{k1}{k2} \times S$
16 < S ≤ 35	16	$\frac{k1}{k2} \times 16$
S > 35	$\frac{S}{2}$	$\frac{k1}{k2} \times \frac{S}{2}$

Where:

k_1 is the value of k for the phase conductor, selected from Table 7-5 according to the materials of both conductor and insulation.

k_2 is the value of k for the protective conductor, selected from Tables 7-6A, 7-6B, 7-6C, 7-6D, or 7-6E, as applicable.

7.2.4 Protective Bonding Conductors (Sizing)

7.2.4.1 Main equipotential bonding conductor required for earthing of an installation shall have a cross-sectional area not less than 6mm^2 copper equivalent and need not exceed 25mm^2 copper equivalent.

7.2.4.2 Where PME conditions apply, the size of the main equipotential bonding conductor shall be selected in accordance with Table 7-7.

7.2.4.3 Where supplementary or additional bonding becomes necessary, the cable size shall not be less than 4mm^2 *[or shall be in accordance with* Table 7-3].

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Table 7-5: Values of k for common materials, for calculation of the effects of fault current

Conductor Material	Insulation Material	Assumed initial temperature (°C)	Limiting final temperature (°C)	k
Copper	70 °C pvc (general purpose) 90 °C pvc 60 °C rubber 85 °C rubber 90 °C thermosetting Impregnated paper	70 90 60 85 90 80	160/140* 160/140* 200 220 250 160	115/103* 100/86* 141 134 143 108
Copper	Mineral − plastic covered or exposed to touch − bare and neither exposed to touch nor in contact with combustible materials	 70 (sheath) 105 (sheath)	 160 250	 115 135
Aluminum	70 °C pvc (general purpose) 90 °C pvc 60 °C rubber 85 °C rubber 90 °C thermosetting Impregnated paper	70 90 60 85 90 80	160/140* 160/140* 200 220 250 160	76/68* 66/57* 93 89 94 71

- *These data are applicable only for disconnection times up to 5 seconds. For longer times the cable manufacturer shall be consulted.*

Table 7-6A: Values of k for insulated protective conductor not incorporated in a cable and not bunched with cables, or for separate bare protective conductor in contact with cable covering but not bunched with cables where the assumed initial temperature is 30 °C

Material of conductor	Insulation of protective conductor or cable covering			
	70 °C PVC	**90 °C** PVC	**85 °C Rubber**	**90 °C Thermosetting**
Copper	143/133*	143/133*	166	176
Aluminum	95/88*	95/88*	110	116
Steel	52	52	60	64
Assumed Initial temperature Final temperature	30 °C 160°C/140°C*	30 °C 160°C/140°C*	30°C 220°C	30°C 250°C
** Above 300 mm²*				

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Table 7-6B: Values of k for protective conductor incorporated in a cable or bunched with cables, where the assumed initial temperature is 70 °C or greater

Material of conductor	**Insulation of protective conductor or cable covering**			
	70 °C PVC	**90 °C** PVC	**85 °C Rubber**	**90 °C Thermosetting**
Copper Aluminum	115/103* 95/88*	100/86* 66/57*	134 89	143 94
Assumed initial temperature Final temperature	70 °C 160 °C/140°C*	90 °C 160°C/140°C*	85 °C 220 °C	90 °C 250 °C
* Above 300 mm^2				

- *Where two values of limiting final temperature and of k are given, the lower value relates to cables having conductors of greater than 300 mm^2 cross-sectional area*

Table 7-6C: Values of k for protective conductor as a sheath or armour of a cable

Material of conductor	Insulation of protective conductor or cable covering			
	70 °C PVC	90 °C PVC	85 °C Rubber	90 °C Thermosetting
Aluminum Steel Lead	93 51 26	85 46 23	93 51 26	85 46 23
Assumed initial temperature Final temperature	60 °C 200 °C	80 °C 200 °C	75 °C 220 °C	80 °C 200 °C

Table 7-6D: Values of k for steel conduit, ducting and trunking as the protective conductor

Material of protective conductor conduit	Insulation material			
	70 °C PVC	90 °C PVC	85 °C Rubber	90 °C Thermosetting
Steel Conduit, Ducting and trunking	47	44	54	58
Assumed initial temperature Final temperature	50 °C 160 °C	60 °C 160 °C	58 °C 220 °C	60 °C 250 °C

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Table 7-6E: Values of k for bare conductor where there is a risk of damage to any neighboring material by the temperatures indicated

Material of conductor	Conditions		
	Visible and in restricted areas	Normal conditions	Fire risk
Copper	228	159	138
Aluminum	125	105	91
Steel	82	85	50
Assumed initial temperature	30 °C	30 °C	30 °C
Final temperature:			
Copper conductors	500 °C	200 °C	150 °C
Aluminum conductors	300 °C	200 °C	150 °C
Steel conductors	500 °C	200 °C	150 °C
NB: The temperatures indicated are valid only where they do not impair the quality of the connections.			

- *Where two values of limiting final temperature and of k are given, the lower value relates to cables having conductors of greater than 300 mm^2 cross-sectional area.*

Table 7-7: Minimum cross-sectional area of the main equipotential bonding conductor in relation to the neutral conductor of the supply

Copper equivalent cross-sectional area of the supply neutral conductor	Minimum copper equivalent cross-sectional area of the main equipotential bonding conductor
35 mm^2 or less	10 mm^2
Over 35 mm^2 up to 50 mm^2	16 mm^2
Over 50 mm^2 up to 95 mm^2	25 mm^2
Over 95 mm^2 up to 150 mm^2	35 mm^2
Over 150 mm^2	50 mm^2
Note: A local service provider's network conditions may require a larger conductor.	

7.3 Connections to Earth

7.3.1 Types of earthing system arrangement

7.3.1.1 The main earthing terminal shall be connected to Earth by one of the methods described in the following provisions under this Code 7.3 as appropriate to the type of earthing system which the installation is to form a part and the earthing lead connected to an effective earth electrode (e.g., copper rod, copper tube or metal plate or earth mat) buried in the ground.

7.3.1.2 For a TN-S system, the main earthing terminal of the installation shall be provided with a means that enables connection to the earthed point of the source of energy supply. The service provider's lines and equipment may form part of the connection.

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7.3.1.3 For a TN-C-S system where protective multiple earthing is the norm, means shall be provided for the main earthing terminal of the installation to be connected to the combined (or protective) earth & neutral (PEN) conductor provided by the service provider.

7.3.1.4 For a TN-C system which use is unusual, the combined earth and neutral wiring is used in both the supply and the installation itself (usually earthed concentric system).

7.3.1.5 For a TT system, the main earthing terminal of the installation shall be connected to earth through an earthing conductor and earth electrode separate from the service provider's neutral conductor.

7.3.1.6 The earthing arrangements may be used jointly or separately for protective and functional purposes, according to the requirements of the installation.

7.3.1.7 The earthing arrangements shall be such that:

(a) the value of impedance from the consumer's main earthing terminal to the earthed point of the supply for TN systems, or to earth for TT systems, is in accordance with the protective and functional requirements of the installation, and considered to be continuously effective, and

(b) earth fault currents and earth leakage currents which may occur are carried without danger, particularly from thermal, thermomechanical and electromechanical stresses, and

(c) they are adequately robust or have additional mechanical protection appropriate to the assessed conditions of external influence.

7.3.1.8 Precautions shall be taken against the risk of damage to other metallic parts through electrolysis.

7.3.1.9 Where several installations have separate earthing arrangements, any protective conductors common to any of these installations shall either be capable of carrying the maximum fault current likely to flow through them or be earthed within one installation only and insulated from the earthing arrangements of any other installation.

Earth Fault Loop Impedance

7.3.2 TN earthing system

7.3.2.1 Each exposed conductive part of the installation shall be connected by a protective conductor to the main earthing terminal of the installation and that terminal shall be connected to the earth point of the supply source in accordance with code 7.3.1 as appropriate.

7.3.2.2 One or more of the following types of protective device shall be used:

(a) an overcurrent protective device; or

(b) a residual current device;

7.3.2.3 Where a residual current device is used in a TN-C-S system, a PEN conductor shall not be used on the load side but shall be connected on the source side of the residual current device.

7.3.2.4 For circuits supplying socket outlets, clause 7.1.8.4 shall apply.

7.3.2.5 For an installation supplied from LV overhead line system, clause 7.1.8.2(b) shall apply for protection against earth leakage.

7.3.2.6 For an installation which is part of a TN system, the limiting values of earth fault loop impedance and of circuit protective conductor impedance specified under this code 7.3.2 (and code 6.4.3) are applicable only where the exposed conductive parts of the equipment concerned, and any extraneous conductive parts are situated **within the earthed equipotential zone** (see also clause 6.4.2.4).

7.3.2.7 For circuits supplying only fixed equipment within the equipotential zone, the earth fault loop impedance at every point of utilization shall be such that disconnection occurs within 0.4 second.

7.3.2.8 Where a circuit supplies fixed equipment outside the earthed equipotential zone the earth fault loop impedance at every point of utilization shall be such that disconnection occurs within the time stated in Table 7-8.

7.3.2.9 Clause 6.3.6.2 is satisfied if the characteristic of each protective device and earth fault loop impedance of each circuit protected by it are such that automatic disconnection of the supply will occur within a specified time when a fault of negligible impedance occurs between a phase conductor and a protective conductor or an exposed-conductor-part anywhere in the installation. This condition shall be satisfied when the following condition is fulfilled:

$$Z_S \leq {}^{U_o}/_{I_a}$$

where:

Z_a is the earth fault loop impedance

I_a is the current causing the automatic operation of the disconnecting protective device within the time stated in Table 7-8 as a function of the nominal voltage Uo or, under the conditions stated in clauses 7.3.2.13 and 7.3.2.14, within a time not exceeding 5s.

U_o is the nominal voltage.

Table 7-8: Maximum Disconnection Times for TN systems (See clause 7.3.2.10)

Installation nominal voltage Uo (Volts)	Maximum disconnection time t (seconds)
230	0.4
400	0.2

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7.3.2.10 The maximum disconnection time of Table 7-8 shall apply to a circuit supplying socket outlets and other final circuits which supply portable equipment intended for manual movement during use, or hand-held Class I equipment.

7.3.2.11 Where a fuse is used to satisfy the requirements of Clause 7.3.2.10,

(a) Maximum values of earth fault loop impedance (Zs) corresponding to a disconnection time of 0.4s are stated in Table 7-9A for a nominal voltage to Earth (Uo) of 230 V; and

(b) for types and rated currents of general purpose (gG) fuses other than those mentioned in Table 7-9A, and for motor circuit fuses (gM), reference must be made to the appropriate British Standard to determine the value of the operating current (Ia) required for compliance with clause 7.3.2.9.

7.3.2.12 Where a circuit-breaker is used to satisfy the requirements of clause 7.3.2.10,

(a) the maximum value of earth fault loop impedance (Zs) shall be determined by the formula of clause 7.3.2.9;

(b) alternatively, for a nominal voltage to earth of 230 V and a disconnection time of 0.4s, the values specified in Table 7-9B for the types and ratings of circuit-breaker listed may be used instead of calculation.

7.3.2.13 For a final circuit which supplies a socket outlet or portable equipment intended for manual movement during use, or hand-held Class I equipment, it shall be permissible to increase the disconnection time to 5s for current protective conductor impedance that does not exceed the corresponding value shown in Table 7-10. The impedance of the protective conductor shall be measured between the output position (or outlet point) to the nearest equipotential bonding.

7.3.2.14 For a distribution circuit, disconnection time not exceeding 5s is permitted.

7.3.2.15 For a distribution board supplying circuits for which a disconnection time of 0.4s is required as well as circuits for which disconnection time of 5s is permitted, one of the following conditions shall be satisfied:

(a) the impedance of the protective conductor between the distribution board and the point at which the conductor is connected to the main equipotential bonding shall not exceed –

(i) the value given in Table 7-10, for the appropriate protective device in the final circuit, or,

(ii) 50Zs/Uo ohms, for protective devices not included in Table 7-10, (where Zs is the earth fault loop impedance corresponding to a disconnection time of 5 s); or

(b) there shall be equipotential bonding at the distribution board, involving the same types of extraneous-conductive parts as the main equipotential bonding according to clause 6.4.2.2 and sized in accordance with code 7.2.4.

7.3.2.16 Where a circuit-breaker is used to satisfy the requirements of clause 7.3.2.14,

(a) the maximum value of earth fault loop impedance (Zs) shall be determined by the formula of clause 7.3.2.9; or

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(b) the values specified in Table 7-9A & B may be used instead of calculation for a nominal voltage to Earth (Uo) of 230 V for the types and ratings of circuit-breaker listed therein.

7.3.2.17 Where a fuse is used to satisfy the requirements of clause 7.3.2.14, maximum values of earth fault loop impedance (Zs) corresponding to a disconnection time of 5s are stated in Table 7-11 for a nominal voltage to Earth (Uo) of 230 V.

7.3.2.18 For types and rated currents of general purpose (gG) fuses other than those mentioned in Table 7-11 and for motor circuit fuses (gM) reference shall be made to the appropriate British Standard to determine the value of the operating current (Ia) for compliance with clause 7.3.2.9**.**

7.3.2.19 If protection is provided by a residual current device the condition of clause 7.1.8.3(a) shall be fulfilled.

7.3.2.20 Where a residual current device is used for automatic disconnection for a circuit which extends beyond the earthed equipotential zone, exposed-conductive parts need not be connected to the TN system protective conductors, provided that they are connected to an earth electrode affording a resistance appropriate to the operating current of the residual current device.

7.3.2.21 A circuit protected using the method described in clause 7.3.2.20 shall be treated as a TT system in which case code 7.3.3 shall apply.

Table 7-9A: Maximum earth fault loop impedance (Zs) for fuses, for 0.4s disconnection time with U_o of 230 V (see clause 7.3.2.11 & also 7.3.2.16)

(a) General purpose (gG) fuses to BS 88 Parts 2 and 6

Rating (amperes)	6	10	16	20	25	32	40	50
Zs (ohms)	8.89	5.33	2.82	1.85	1.50	1.09	0.86	0.63

(b) Fuses to BS 1361

Rating (amperes)	5	15	20	30	45
Zs (ohms)	10.9	3.43	1.78	1.20	0.60

(c) Fuses to BS 3036

Rating (amperes)	5	15	20	30	45
Zs (ohms)	10.0	2.67	1.85	1.14	0.62

(d) Fuses to BS 1362

Rating (amperes)	13
Zs (ohms)	2.53

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly.

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Table 7-9B: Maximum earth fault loop impedance (Zs) for circuit-breakers with Uo of 230 V, for instantaneous operation giving compliance with the 0.4 second disconnection time of clause 7.3.2.12 & also clause 7.3.2.16

(a) Type 1 miniature circuit-breakers to BS 3871

Rating(amperes)	5	6	10	15	16	20	25	30	32	40	45	50	63	In
Zs (ohms)	12		6		3.75		2.4		1.88		1.33		0.95	60/In
		10		4		3		2		1.5		1.2		

(b) Type 2 miniature circuit-breakers to BS 3871

Rating(amperes)	5	6	10	15	16	20	25	30	32	40	45	50	63	In
Zs (ohms)	6.86		3.43		2.14		1.37		1.07		0.76		0.54	34.3/In
		5.71		2.29		1.71		1.14		0.86		0.69		

(c) Type B circuit-breakers to BS EN 60898

Rating(amperes)	6	10	16	20	25	32	40	45	50	63	In
Zs (ohms)	8.0		3.0		1.92	1.50		1.07		0.76	48/In
		4.80		2.40			1.20		0 .96		

(d) Type 3 miniature circuit-breakers to BS 3871 and Type C circuit-breakers to BS EN 60898

Rating(amperes)	5	6	10	15	16	20	25	30	32	40	45	50	63	In
Zs (ohms)	4.80		2.40		1.50		0.96		0.75		0.53		0.38	24/In
		4.00		1.60		1.20		0.80		0.60		0.48		

(e) Type D circuit-breakers to BS EN 60898

Rating(amperes)	5	6	10	15	16	20	25	30	32	40	45	50	63	In
Zs (ohms)	2.40		1.20		0.75		0.48		0.38		0.27		0.19	12/In
		2.00		0.80		0.60		0.40		0.30		0.24		

NOTE: The circuit loop impedances given in the table must not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading shall be adjusted accordingly.

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Table 7-10: Maximum impedance of circuit protective conductor related to the final circuit protective device (see clause 7.3.2.13 & also 7.3.2.15)

(a) General purpose (gG) fuses to BS 88 Parts 2 and 6

Rating (amperes)	6	10	16	20	25	32	40	50
Impedance (ohms)	2.48	1.48	0.83	0.55	0.43	0.34	0.26	0.19

(b) Fuses to BS 1361

Rating (amperes)	5	15	20	30	45
Impedance (ohms)	3.25	0.96	0.55	0.36	0.18

(c) Fuses to BS 3036

Rating (amperes)	5	15	20	30	45
Impedance (ohms)	3.25	0.96	0.63	0.43	0.24

(d) Fuses to BS 1362

Rating (amperes)	13
Impedance (ohms)	2.53

(e) Type 1 miniature circuit-breakers to BS 3871

Rating(amperes)	5	6	10	15	16	20	30	32	40	45	50	63	In
Impedance (ohms)	2.50		1.25		0.78		0.42		0.31		0.25		12.5/In
		2.08		0.83		0.63		0.39		0.28		0.2	

(f) Type 2 miniature circuit-breakers to BS 3871

Rating (amperes)	5	6	10	15	16	20	30	32	40	45	50	63	In
Impedance (ohms)	1.43		0.71		0.45		0.24		0.18		0.14		7.14/In
		1.19		0.48		0.36		0.22		0.16		0.11	

(g) Type B circuit-breakers to BS EN 60898

Rating(amperes)	6	10	16	20	32	40	45	50	63	In
Impedance (ohms)	1.67		0.63		0.31		0.22		0.16	
		1.00		0.50		0.25		0.20		10/In

(h) Type 3 miniature circuit-breakers to BS 3871 and Type C circuit-breakers to BS EN 60898

Rating(amperes)	5	6	10	15	16	20	30	32	40	45	50	63	In
Impedance (ohms)	1.00		0.50		0.31		0.17		0.13		0.10		5/In
		0.83		0.33		0.25		0.16		0.11		0.08	

(i) Type D circuit-breakers to BS EN 60898

Rating(amperes)	5	6	10	16	20	25	32	40	45	50	63	In
Zs (ohms)	0.5		0.25	0.16		0.10	0.08		0.06		0.04	2.5/In
		0.42			0.12			0.06		0.05		

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly.

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Table 7-11: Maximum earth loop impedance (Zs) for 5s disconnection time with Uo of 230V (see clauses 7.3.2.17 and 7.3.2.18)

(a) General purpose (gG) fuses to BS 88 Parts 2 and 6

Rating (amperes)	6	10	16	20	25	32	40	50
Zs (ohms)	14.1	7.74	4.36	3.04	2.40	1.92	1.41	1.09

Rating (amperes)	63	80	100	125	160	200
Zs (ohms)	0.86	0.60	0.44	0.35	0.27	0.20

(b) Fuses to BS 1361

Rating (amperes)	5	15	20	30	45	60	80	100
Zs (ohms)	17.1	5.22	2.93	1.92	1.00	0.73	0.52	0.38

(c) Fuses to BS 1362

Rating (amperes)	5	15	20	30	45	60	100
Zs (ohms)	18.5	5.58	4.00	2.76	1.66	1.17	0.56

(d) Fuses to BS 1362

Rating (amperes)	13
Zs (ohms)	4

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly.

7.3.3 TT earthing system

7.3.3.1 Every exposed conductive part which is to be protected by a single protective device shall be connected, through the main earthing terminal, to a common earth electrode.

7.3.3.2 Where several protective devices are in series, the exposed conductive parts may be connected to separate earth electrodes corresponding to each protective device.

7.3.3.3 One or more of the following types of protective devices shall be used, preferably the residual current device:

(a) a residual current device

(b) an overcurrent protective device.

7.3.3.4 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 5s.

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

7.3.3.6 Where a residual current device (RCD) is used to protect a circuit, the maximum earth fault loop impedance of that circuit shall not exceed those given in Table 7-12.

Table 7-12: Maximum Earth Fault Loop Impedance when a Circuit is Protected by a Residual Current Device (RCD)

Rated Residual Operating Current, $I_{\Delta n}$ (mA)	30	100	300	500
Earth fault Loop Impedance, Zs (ohm)	1667	500	167	100

7.3.4 Earth electrodes

7.3.4.1 The following types of earth electrodes are recognized under this LEWC:

(a) Earth rods or pipes;
(b) Earth tapes or wires;
(c) Earth mats or plates;
(d) Underground structural metal work embedded in foundations;
(e) Metallic reinforcement in concrete structures;
(f) Underground metallic pipe systems, excluding public gas and water systems; and
(g) Lead sheaths and metallic covering of underground cables (permission required for use of these).

7.3.4.2 The type and embedded depth of an earth electrode shall be such that soil drying will not increase its resistance above the required value

7.3.4.3 The earth electrode shall be designed and constructed such as to withstand damage and to take account of possible increase in resistance due to corrosion.

7.3.4.4 The metalwork of a gas, water or other service shall not be used as a protective earth electrode although they must be bonded to earth as required by clause 6.4.2.2.

7.3.4.5 Lead sheath or other metal covering of a cable may be used as earth electrode subject to the following conditions:

(a) adequate precautions must be taken to prevent excessive deterioration by corrosion;
(b) the sheath or covering shall be in effective contact with earth;
(c) the consent of the owner of the cable must be sought; and
(d) arrangements shall exist for the owner of the electrical installation to be warned of any proposed change to the cable which might affect its suitability as an earth electrode.

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7.3.5 Earthing conductors

7.3.5.1 An earthing conductor shall comply with Code 7.2, particularly codes 7.2.2 and 7.2.3. and in addition, where buried in the ground, it shall have a cross-sectional area not less than that stated in Table 7-13.

7.3.5.2 For a tape or strip earthing conductor, the thickness shall be such as to withstand mechanical damage and corrosion.

7.3.5.3 Protection of bare earthing wire shall be ensured by passing it through a conduit tube from the building to the point of connection to the electrode.

7.3.5.4 The connection of an earthing conductor to an earth electrode or other means of earthing shall be:

(a) soundly made;
(b) electrically and mechanically satisfactory;
(c) suitably protected against corrosion; and
(d) labeled in accordance with code 11.3.1.

7.3.5.5 Aluminum and copper clad aluminum conductors shall not be used as earthing conductors for final connections to earth electrodes. Copper conductors or other suitable materials with equivalent resistance to corrosion must be used.

Table 7-13: Minimum cross-sectional area of a buried earthing conductor

Earthing conductor Corrosion protection status	**Protection against mechanical damage**	
	Required	**Not Required**
Protection against corrosion by a sheath	As required by code 7.2.3	16 mm^2 copper 16 mm^2 coated steel
Not protected against corrosion	25 mm^2 copper 50 mm^2 steel	25 mm^2 copper 50 mm^2 steel

7.3.6 Main earthing terminals or bars and earthing arrangement

7.3.6.1 The main earthing terminal shall be connected to Earth by one of the methods described in code 7.3.1 as appropriate to the type of system of which the installation is to form a part and the earthing lead connected to an effective earth electrode (e.g., copper rod, copper tube or metal plate or earth mat) buried in the ground.

7.3.6.2 In every installation, a main earthing terminal or bar shall be provided to connect or be bonded together with the following conductors to the earthing conductor:

(a) the circuit protective conductors;
(b) the main bonding conductors;
(c) functional earthing conductors (if required); and
(d) lightning protection system bonding conductor, if any.

7.3.6.3 The main earthing terminal shall be effectively connected to the earth electrode(s) by the earthing conductor

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7.3.6.4 An accessible position and means for disconnecting the earthing conductor (test link) shall be provided to facilitate testing and measurement of the resistance of the earthing arrangement and such means may be conveniently combined with the main earthing terminal or bar.

7.3.6.5 Any joint shall be capable of disconnection only by means of a tool and shall be mechanically strong and ensure the maintenance of electrical continuity.

Bonding Connections to the Point of Supply by Transformer

7.3.6.6 Where the supply is taken directly from the service provider's transformer(s) within the premises in which the installation is situated, the main earthing terminal of the installation shall be bonded by a conductor or through a common conductor to a bonding terminal provided by the service provider at the point of supply, (for example, near the main cable terminations on the incoming circuit breakers).

7.3.6.7 The size of bonding conductor connecting the consumer's main earthing terminal and the service provider's transformer earth or metallic sheaths of service cable, shall not be less than 150mm^2 copper equivalent.

Connections to Supply by underground cable

7.3.6.8 Where the supply is taken from the service provider's underground cable(s) having exposed conductive parts, such as metallic cable endbox, metallic cable glands, cable armor or metallic sheath etc., at the cable termination at the point of supply, the main earthing terminal of the installation shall be bonded to these exposed conductive parts using bonding terminal(s) provided by the service provider.

7.3.6.9 The main equipotential bonding connection to any gas, water or other service shall be made as near as practicable to the point of entry of that service into the premises. Where there is an insulating section or insert at that point, or there is a meter, the connection shall be made to the consumer's hard metal pipework and before any branch pipework. Where practicable the connection shall be made within 600 mm of the meter outlet union or at the point of entry to the building if the meter is external.

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PART D

CODE 8: CONDUCTORS, JOINTS, CONNECTIONS AND ACCESSORIES

8.1 Selection and Sizing of Cable Conductors

8.1.1 General

8.1.1.1 All cable conductors including those listed under this clause 8.1.1.1 shall meet the requirements of the relevant Liberia Standards or equivalent international standards and as may be recommended for use by the Service Provider:

(a) Single core, PVC insulated and/or sheathed cables.
(b) Multi core, PVC insulated and/or sheathed cables.
(c) Mineral-insulated metal-sheathed cables; (e.g., MICC)
(d) Aluminum sheathed cables;
(e) Vulcanized rubber insulated (VRI) cables; and
(f) Tough rubber sheathed (TRS) cables.

8.1.1.2 Cable conductors shall be so selected and installed that they are not subjected to deterioration from electromechanical stress, vibration, moisture, corrosive liquids, oil or heat arising during service or fault.

8.1.1.3 Where it is impossible practically to avoid the conditions stated in clause 8.1.1.2, the cable conductor shall be protected or shielded against such conditions of deterioration or else only cables specially designed to withstand such conditions shall be used.

8.1.1.4 Only insulated flexible cables and cords, protected by armor, tough-rubber or P.V.C sheath shall be used for fixed wiring in places such as workshops where they may be subjected to abnormal risk of mechanical damage.

8.1.1.5 All electrical cables shall be of sufficient size and have a current-carrying capacity not less than the maximum current demand that it normally carries for the purposes for which they are intended.

8.1.2 Factors considered in sizing of cable conductors

8.1.2.1 The minimum size of a copper conductor shall be 1.5mm^2 and a cable conductor shall be:

(a) capable of withstanding the prospective fault current;
(b) suitable for operation in the environment; and
(c) appropriate for the design voltage of the installation.

8.1.2.2 The sizing of cable conductors shall consider the following factors:

(a) the conductor material;
(b) the insulation material;
(c) the ambient temperature in which the cable is installed;
(d) the method of installation;

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(e) whether or not the cable is affected by thermal insulating material;
(f) the use and type of protective device;
(g) the voltage drop from the origin of the circuit to the load;
(h) reference to the manufacturer's recommendation;

8.1.3 Method of sizing cable conductors

8.1.3.1 The following steps shall be employed in determining the size of cable conductors for use:
(a) Determine the design current of the circuit under consideration.
(b) Choose a suitable overcurrent protective device (refer to Code 7.1).
(c) Determine the current-carrying capacity of the conductors required by applying suitable rating factors to the nominal setting or current rating of the overcurrent protective device as divisors. [Typical rating factors for ambient temperature, grouping, thermal insulation and type of protective device can be accessed from BS 7671:2018**.]**
(d) Choose a suitable size of the conductors according to the current-carrying capacity required [Refer to BS 7671:2018 for assistance]
(e) Check the resulting voltage drop in the circuit so that under normal service conditions the voltage at the terminals of any fixed current-using equipment shall be greater than the lower limit corresponding to the recognized standards relevant to the equipment.

8.1.3.2 Where the fixed current-using equipment concerned is not the subject of a recognized standard, the voltage at the terminals shall be such as not to impair the safe function of that equipment.

8.1.3.3 The requirements of clause 8.1.3.2 are deemed to be satisfied if the voltage drop between the origin of the installation (usually the supply terminals) and the fixed current-using equipment does not exceed 4% of the nominal voltage of the supply.

8.1.3.4 A greater voltage drop may be accepted for a motor during starting periods and for other equipment with high inrush current, provided that:
(a) voltage variations are within the limits specified in the relevant recognized standards for the equipment; or
(b) in the absence of a recognized standard, in accordance with the manufacturer's recommendations.

8.1.3.5 The references provided in BS 7671:2018 may be relied upon for estimation of the values of voltage drop caused by one ampere for a meter-run of PVC/XLPE insulated cables with copper conductors. If the voltage drops so determined is unsatisfactory, a conductor of larger size shall be chosen accordingly.

8.1.4 Typical sizes of cable conductor for general installations

8.1.4.1 The sizes of copper conductor in compliance with Table 8-1 are generally acceptable for general installations under the following conditions:
(a) the ambient temperature shall not exceed 35°C;
(b) no more than one circuit of single core cables or one multicore cable shall

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be grouped together;

(c) the spacing between groups of single core cables or multicore cables for cables clipped direct on surface shall not be less than twice the diameter of the largest cable in the adjacent group of cables;

(d) the protective device shall not be a semi-enclosed fuse; and

(e) the cables shall not be in contact with any thermal insulation.

Table 8-1: Minimum Size of PVC Copper Conductors in sq. mm under the General Installation Conditions Listed in code 8.1.4

	Current Rating (Amp)	Enclosed Condition (mm^2)	Clipped Direct (mm^2)
Single Phase 2-wire	5	1.0	1.5
	10	1.0	1.5
	15	2.5	2.5
	20	2.5	2.5
	30	4	4
	60	16	10
	80	25	16
	100	35	25
Three Phase 4-wire	5	1.0	1.5
	10	1.0	1.5
	15	2.5	2.5
	20	2.5	2.5
	30	6	4
	60	16	10
	100	35	25
	150	70	50
	200	120	70
	300	240	150
	400	400	240

8.2 Basic Protection of Cable conductor

8.2.1 Protection by electrical Insulation

8.2.1.1 Live conductors shall be completely covered with insulation which:

(a) is durable to withstand the mechanical, electrical, thermal and chemical stresses to which it may be subjected in service; and

(b) can only be removed by destruction.

8.2.1.2 Where insulation is applied during the erection of the installation, the quality of the insulation shall be verified by tests equivalent to those specified in recognized standards for similar type-tested equipment.

8.2.1.3 Non-impregnated paper, asbestos, fabric, wood or press-hemp shall not be used

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for insulating purposes.

8.2.2.4 Where insulating tapes are permitted to be used in LV installations, they shall have a minimum thickness of 0.21mm^2.

8.2.2 Protection by other means

8.2.2.1 Other means of basic protection as stipulated in IEC 60364, or other relevant international standards are acceptable.

8.3 Identification of Conductors & Cables

8.3.1 General

8.3.1.1 All cables shall be marked to indicate the following information using appropriate codes provided by the Liberia Standards Authority or any other recognized institutions:

(a) the maximum working voltage for which the cable is tested and/or approved;
(b) the manufacturers name, trademark etc; and
(c) the size or cross-sectional area.

8.3.1.2 Subject to code 8.3.2, every core of a cable shall be identifiable by color at its terminations and preferably throughout its length.

Protective Conductor

8.3.1.3 The bi-color combination of green-and-yellow (30:70 ratio) is reserved exclusively for identification of a protective conductor and shall not be used for any other purpose.

8.3.1.4 A bare conductor or busbar used as a protective conductor shall be identified, where necessary, by equal green and yellow stripes, each not less than 15 mm and not more than 100 mm wide, close together, either throughout the length of the conductor or in each compartment and unit and at each accessible position.

8.3.1.5 Where adhesive tape is used, it shall be bi-colored.

Neutral Conductor

8.3.1.6 The neutral conductor shall be identified by the blue color.

PEN Conductor

8.3.1.7 The following color coding shall mark an insulated PEN conductor:

(a) green-and-yellow throughout its length with blue markings at the terminations, or
(b) blue throughout its length with green-and-yellow markings at the terminations.

8.3.1.8 The single-color green shall not be used.

Others

8.3.1.9 A bare conductor shall be identified, where necessary, by the application of tape, sleeve or disc of the appropriate color prescribed in Table 8-3 or by painting with such a color.

8.3.1.10 This LEWC relies on *BS 7671* for color identification of conductors and cables. Some cables comply with *HD 324:1977* and have blue insulation on the neutral conductor contrary to the specifications in code 8.3.2.

8.3.1.11 Where such cables are used, they must be correctly identified at their terminations by the use of black cable markers or black tape.

8.3.2 Distinctive colors for cables

8.3.2.1 The distinctive colors for flexible cords or cables shall be as shown in Table 8-2.

Table 8-2 : Color identification of cores of flexible cables and flexible cords

Number of cores	Function of core	Color(s) of core
1	Phase Neutral Protective (Earth Wire)	Brown or Red Blue Green-and- Yellow
2	Phase Neutral	Brown (or Red) Blue*
3	Phase Neutral Protective (Earth Wire)	Brown** (or Red) Blue* Green-and- Yellow
4 or 5	Phase Neutral Protective (Earth Wire)	Brown or Black+ Blue* Green-and- Yellow

(*) The blue core may be used for functions other than the neutral in circuits which do not incorporate a neutral conductor, in which case its function shall be appropriately identified during installation; provided that the blue core shall not in any event be used as a protective conductor. If the blue core is used for other functions, the coding Ll, L2, L3, or other coding where appropriate should be used.

(**) In three-core flexible cables or flexible cords not incorporating a green-and-yellow core, brown core and a black core may be used as phase conductors.

(+) Where an indication of phase rotation is desired, or it is desired to distinguish the function of more than one phase core of the same color, this shall be by the application of numbered or lettered (not colored) sleeves to the cores, preferably using the coding Ll, L2, L3 or other coding where appropriate.

8.3.2.2 Unlike the cores of fixed cables, which may be identified by sleeves or tapes where they are connected, flexibles cables must be identified throughout their length.

8.3.2.3 The distinctive colors for non-flexible cords or cables shall be as shown in Table 8-3.

8.3.2.4 Armored PVC-insulated auxiliary cables shall be identifiable using:

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(a) core colors in accordance with the requirements of Table 8-3; or
(b) the application at terminations of tapes, sleeves or discs of the appropriate prescribed colors; or
(c) alternatively, by using numbered cores in accordance with BS 6346.

Table 8-3: Color identification of cores of non-flexible cables and bare conductors (for fixed wiring) BS7671

Function	Color identification	Alphanumeric or letter Coding
A. For AC Installation		
Phase of single-phase circuit	Red (or yellow or blue)	L
Phase 1 of 3-phase circuit	Red	L1
Phase 2 of 3-phase circuit	Yellow	L2
Phase 3 of 3-phase circuit	Blue	L3
Neutral of single-phase or three-phase circuit	Black	N
Protective (including earthing) conductor	Green-and-Yellow	E or '—'
B. For DC Installation (2-Wire Unearthed DC power circuit)		
Positive of DC 2-wire circuit	Brown	L^+
Negative of DC 2-wire circuit	Grey	L^-
C. For DC Installation (2-Wire Earthed DC power circuit)		
Outer (positive or negative) of DC 2-wire circuit derived from 3-wire system	Red	
Positive of 3-wire DC circuit	red	
Middle wire of 3-wire circuit	black	
Negative of 3-wire DC circuit	blue	
Positive (of negative earthed) circuit	Brown	L^+
Negative (of negative earthed) circuit	Blue	M
Positive (of positive earthed) circuit	Blue	M
Negative (of positive earthed) circuit	Grey	L^-

8.3.2.5 For paper-insulated cables, identification shall be by using numbered cores in accordance with **BS 6480;** provided that the numbers 1, 2 and 3 shall signify phase conductors, the number 0 being the neutral conductor, and the number 4 being the fifth (or 'special purpose') core, if any.

8.3.2.6 These colors shall be used for marking all installations of conductors and/or in distribution fuse board or busbars.

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8.3.3 Identification of conductors by letters and/or numbers

8.3.3.1 Individual conductors and conductors in a group shall be identified by lettering or Arabic numeral system as specified in Table 8-3.

8.3.3.2 The identification shall be clearly legible and durable, and all numerals shall be in strong contrast to the color of the insulation.

Protective Conductor

8.3.3.3 Conductors with green-and-yellow color identification shall not be numbered other than for the purpose of circuit identification.

8.3.3.4 Conductors may be identified by numbers, the number 0 being reserved for the neutral or mid-point conductor.

8.3.4 Identification of cables buried direct in ground

8.3.4.1 Where cables are buried underground, they shall be identified by cable cover tiles or identification tapes for the entire underground cable route.

8.3.4.2 The cable tiles or identification tapes shall be marked with the words ***'Danger-cables'***.

8.3.5 Omission of identification by color or marking

8.3.5.1 Identification by color or marking shall not be required for:

(a) concentric conductors of cables;
(b) metal sheath or armor of cables when used as a protective conductor;
(c) bare conductors where permanent identification is not practicable;
(d) extraneous-conductive parts used as a protective conductor; or
(e) exposed-conductive parts used as a protective conductor.

8.4 Cable Installation Enclosure

8.4.1 General

8.4.1.1 Cables shall be installed in such positions where they will not be affected by the sun or rain or any other condition, except when specially designed for this purpose.

8.4.1.2 Cables shall not be buried directly into any wall, floor or ceiling but may be concealed in one of the following ways:

(a) P.V.C. insulated and sheathed in "duct tube", in wood ducts or on the surface and may be drawn in the hollow flooring after the concrete has been laid; and
(b) P.V.C. insulated cable may be drawn in heavy gauge galvanized steel conduit or plastic conduit of a type approved by the Service Provider.

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Steel conduits

8.4.1.3 Steel conduits and fitting with metric thread, except flexible conduits, must be of heavy gauge, longitudinally welded type and comply with IEC 61386 or equivalent.

8.4.1.4 Where flexible conduits are exposed to weather or in damp situations, the conduits shall be of the metallic type with PVC oversheath.

8.4.1.5 All steel conduits, conduit fittings and the associated metallic boxes for the enclosure of electrical accessories shall be protected against corrosion on both the inside and outside surfaces.

Steel Trunking

8.4.1.6 Steel trunking and fittings shall be fabricated with sheet steel having a minimum thickness as indicated in Table 8-4 and shall comply with the requirements specified in BS 4678: Part 1 or equivalent.

8.4.1.7 Steel trunking installations shall be constructed using manufacturer's standard fittings such as tee or angle pieces, connectors etc., throughout as far as practicable and shall be protected against corrosion.

Plastic or PVC Conduit or Trunking

8.4.1.8 Rigid plastic or PVC conduits and conduit fittings including pliable conduits shall be made of such material and be of such strength to withstand the stress under the installed conditions complying with BS 4607, IEC 61386 or other equivalent standard as appropriate.

8.4.1.9 Adaptable boxes and boxes for the enclosure of electrical accessories that are made of insulating materials shall comply with BS 4662 or equivalent and have a minimum wall thickness of 2mm.

Table 8.4: Minimum Thickness of Body Material for Metallic Trunking

Nominal Size (mm × mm)	Minimum Thickness of Body Material (in mm)
50 × 50	1.0
75 × 50	1.2
75 × 75	1.2
100 × 75	1.2
150 × 100	1.4
150 × 150	1.6
Note: Metallic trunkings having nominal size differing from the table but complying with IEC 61084 or equivalent are also acceptable	

8.4.2 Determination of cable capacity of enclosures

8.4.2.1 The numbers of cables drawn into, or laid in, an enclosure of a wiring installation shall be determined taking into consideration several factors including the following:

(a) reasonable care of drawing-in the cable;
(b) acceptable use of the space available;
(c) tolerance in cable sizes; and

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(d) tolerance of the conduit and trunking product.

8.4.2.2 Despite the various factors mentioned in clause 8.4.2.1, only the ease of achieving the cable drawing-in process to avoid damage to the cable is considered in this LEWC.

8.4.2.3 To ensure an easy pull with low risk of damage to cables through conduit and trunking enclosures, guidance as to the size and number of cables to fit appropriate enclosures is provided using the "unit system method" described in this code 8.4.2 for single-core PVC insulated cables for the following different types of installations:

(a) straight runs of conduit not exceeding 3m in length;
(b) straight runs of conduit exceeding 3m in length, or in runs of any length incorporating bends or sets; and
(c) trunking.

8.4.2.4 For HV or other cables and/or conduits not covered in this LEWC, recommendation on the number of cables that can be drawn-in for an enclosure shall be obtained from manufacturers.

Straight runs of conduit not exceeding 3m in length:

8.4.2.5 For straight runs of conduit not exceeding 3m in length, the following steps shall be used:

Step 1: For each cable that is to be used, obtain the appropriate cable factor from Table 8-5A.

Step 2: Add up all the cable factors obtained from Step 1 and compare the summed total with the conduit factors provided in Table 8-5B.

Step 3: Select the minimum conduit size that corresponds with the conduit factor equal to or greater than the sum of the cable factors obtained from Step 2.

Table 8-5A: Cable factors for short straight-runs use in conduits

Type of Conductor	Conductor cross-sectional area (mm^2)	Cable factor
Solid	1	22
	1.5	27
	2.5	39
Stranded	1.5	31
	2.5	43
	4	58
	6	88
	10	146
	16	202
	25	385

Table 8-5B: Conduit factors for use in short straight-runs

Conduit diameter (mm)	Conduit Factor (= sum of cable factors)
16	290
20	460
25	800
32	1400
38	1900
50	3500
63	5600

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Straight runs of conduit exceeding 3m in length or in runs of any length incorporating bends or sets:

8.4.2.6 For straight runs of conduit exceeding 3m in length or in runs of any length incorporating bends or sets the following steps are used:

Step 1: For each cable that is to be used obtain the appropriate cable factor from Table 8-5C.

Step 2: Add up all the cable factors obtained from Step 1 and compare the summed total *(referred to as conduit factor)* with the conduit factors given in Table 8-5D, considering the length of run and number of bends in that run.

Step 3: Select the minimum conduit size that corresponds with the conduit factor equal to or greater than the sum of the cable factors obtained from Step 2.

(NB: The term 'bend' signifies a 90° bend, and one "double set" is equivalent to one bend.)

Trunking of any length of run:

8.4.2.7 For Trunking of any length of run, the following steps are used:

Step 1: For each cable that is to be used obtain the appropriate cable factor from Table 8-5E.

Step 2: Add up all the cable factors obtained from Step 1 and compare the summed total with the trunking factors given in Table 8-5F.

Step 3: Select the minimum trunking size that corresponds with the trunking factor (or term) equal to or greater than the sum of the cable factors obtained from Step 2.

8.4.2.8 For sizes and types of cable, and sizes of trunking other than those given in Tables 8-5E & 8-5F, the number of cables drawn into a trunking must be such that the resulting space factor does not exceed 45%.

Table 8-5C: Cable factors for use in conduits for long straight runs over 3 m, or runs of any length incorporating bends

Type of conductor	Conductor cross-sectional area mm^2	Cable factor
Solid or Stranded	1	16
	1.5	22
	2.5	30
	4	43
	6	58
	10	105
	16	145
	25	217

LDS

Table 8-5D: Conduit factors for runs incorporating bends and long straight runs

Length of run (m)	Conduit diameter, mm															
	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
	Straight				One bend				Two bends				Three bends			
1					188	303	543	947	177	286	514	900	158	256	463	818
1.5					182	294	528	923	167	270	587	857	143	233	422	750
2					177	286	514	900	158	256	463	818	130	213	388	692
2.5					171	278	500	878	150	244	442	783	120	196	358	643
3					167	270	487	857	143	233	422	750	111	182	333	300
3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563
4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500
5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
6	167	270	487	857	143	233	422	750	111	182	333	600				
7	162	263	475	837	136	222	404	720	103	169	311	563				
8	158	256	463	818	130	213	388	692	97	159	292	529				
9	154	250	452	800	125	204	373	667	91	149	275	500				
10	150	244	442	783	120	196	358	643	86	141	260	474				

Additional Factors: For 38 mm diameter use…….... 1.4 x (32 mm term)
For 50 mm diameter use ……... 2.6 x (32 mm term)
For 63 mm diameter use ……... 4.2 x (32 mm term)

Table 8-5E: Cable factors for trunking

Type of conductor	Conductor cross-sectional area mm²	Cable factor (for PVC insulation)	Cable factor (for thermosetting insulation)
Solid	1.5	8.0	8.6
	2.5	11.9	11.9
Stranded	1.5	8.6	9.1
	2.5	12.6	13.9
	4	16.6	18.1
	6	21.2	22.9
	10	35.3	36.3
	16	47.8	50.3
	25	73.9	75.4

Notes

(i) These factors are for metal trunking and may be optimistic for plastic trunking where the cross-sectional area available may be significantly reduced from the nominal by the thickness of the wall material.

(ii) The provision of spare space is advisable; however, any circuits added at a later date must take into account grouping.

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Table 8-5F: Truncking Factors (Terms)

Dimensions of trunking (mm x mm)	Factor (Term)	Dimensions of trunking [Cont'd] (mm x mm)	Factor (Term)
50 x 38	767	200 x 100	8572
50 x 50	1037	200 x 150	13001
75 x 25	738	200 x 200	17429
75 x 38	1146	225 x 38	3474
75 x 50	1555	225 x 50	4671
75 x 75	2371	225 x 75	7167
100 x 25	993	225 x 100	9662
100 x 38	1542	225 x 150	14652
100 x 50	2091	225 x 200	19643
100 x 75	3189	225 x 225	22138
100 x 100	4252	300 x 38	4648
150 x 38	2999	300 x 50	6251
150 x 50	3091	300 x 75	9590
150 x 75	4743	300 x 100	12929
150 x 100	6394	300 x 150	19607
150 x 150	9697	300 x 200	26285
200 x 38	3082	300 x 225	29624
200 x 50	4145	300 x 300	39428
200 x 75	6359		

LDS

Wiring Installation Works

8.5 Cable Enclosure Installations

8.5.1 Wiring installation using conduits -Steel, PVC or Plastic

General requirements

8.5.1.1 Where a conduit crosses an expansion joint,

(a) Special arrangements shall be made to allow relative movement to occur on either side of the expansion joint.

(b) A separate circuit protective conductor shall be installed to maintain an effective electrical continuity across the expansion joint.

(c) The circuit protective conductor shall have a cross-sectional area rated to suit the largest live conductor drawn into the conduit.

8.5.1.2 During construction works,

(a) all open ends of the conduit termination which are liable to be filled with water, moisture or other foreign matter, shall be plugged with proper conduit stopping plugs; and

(b) conduit boxes shall be plugged to prevent concrete or plaster from entering the boxes.

8.5.1.3 Proper sealant for the prevention of accumulation of condensed moisture shall be applied to ceiling conduit outlets installed in a cool space subject to the influx of warm air.

8.5.1.4 Saddles, for the support of surface conduits, shall be provided throughout the entire route at regular intervals with spacing between adjacent saddles not being greater than those given in Table 8-6.

8.5.1.5 Cables shall be drawn into a conduit by using drawn-in tape or steel wire of the appropriate size. Where cable lubricant is used, it shall not:

(a) negatively interact with the cable they lubricate; and

(b) must not increase the flame spread or decrease the fire-resistant properties of the cable.

8.5.1.6 All live conductors of the same circuit shall be drawn into the same conduit.

8.5.1.7 The neutral cable of a lighting final circuit using single core cables may be routed in the conduit direct to the lighting point without passing through the switch box.

8.5.1.8 Adaptable boxes shall be provided:

(a) immediately after every two bends; or

(b) after a bend plus a total maximum straight run of 10m; or

(c) after a maximum straight run of 15m.

8.5.1.9 Adjacent or parallel conduits cast in concrete shall be separated by a spacing of not less than 25mm.

8.5.1.10 Conduits shall not be bent in such a manner which appreciably distorts their original cross-sectional shape or causes damage to the conduits.

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8.5.1.11 Burrs, sharp edges and projections shall be removed from the internal surfaces and ends of conduits, trunking or other enclosures when installed and the ends of lengths of conduit shall be so trimmed and the outlets shall be so bushed, as to obviate abrasion of cables.

8.5.1.12 In conduit system, the conduits for each circuit shall be erected complete before any cable is drawn in.

8.5.1.13 It is desirable that inspection boxes, drawn-in boxes, etc. shall remain accessible throughout the life of the installation for purposes such as the withdrawal of existing cables or the installing of additional cables.

Table 8-6: Spacing of Supports for Conduits

Conduit Size (S) in mm	Maximum Distance between Supports (Meters)					
	Rigid Steel		Rigid Plastic/PVC		Pliable	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
S≤16	0.75	1.0	0.75	1.0	0.3	0.5
16<S≤25	1.75	2.0	1.5	1.75	0.4	0.6
25<S≤40	2.0	2.25	1.75	2.0	0.6	0.8
40<S	2.25	2.5	2.0	2.0	0.8	1.0

Wiring installation using steel conduit

8.5.1.14 A steel conduit joint shall be made using a solid coupler into which the adjacent ends of the two conduits must be inserted and screwed up tightly in order to make the conduit run mechanically and electrically continuous, and any exposed screw threads must be painted with anti-corrosion paint.

8.5.1.15 Running couplings are not recommended.

8.5.1.16 Where a steel conduit terminates at a metal casing, the connection shall be made using a coupler or a brass adaptor for flexible conduit together with a brass male bush.

8.5.1.17 The connection between the flexible conduit and the adaptor shall be securely fixed and protected against ingress of moisture where required.

8.5.1.18 The length of each flexible conduit shall be kept to a minimum of not more than:
(a) 1m for general applications; or
(b) 2m inside false ceiling.

8.5.1.19 All metal conduit and metal-sheathed systems shall have the conduit or metallic sheath electrically bonded to the earth in a sound manner.

8.5.1.20 Where the metal casing is painted or enameled, the electrical continuity between the conduit and the casing shall be achieved by means of a separate protective conductor of adequate size, connecting the earthing terminal of the conduit and an earthing terminal inside the metal casing.

LDS

8.5.1.21 A conduit should not be bent more than 90 degrees. The internal radius of the bend shall not be less than 2.5 times the outside diameter of the conduit.

8.5.1.22 Where the protective coating on a metallic enclosure has been damaged after installation, such surface shall be effectively restored by paint or other suitable coating to prevent corrosion.

Wiring installation using PVC or plastic conduit

8.5.1.23 A conduit bend shall have an internal radius of at least 4 times the outside diameter of the conduit.

8.5.1.24 The method of carrying out the conduit bends, conduit joints, fixing conduits to boxes without spouts, and the tools and materials to be used shall be as recommended by the manufacturer of the conduits.

8.5.1.25 Adequate allowance shall be made for the expansion of the PVC tubing at high temperatures using expansion coupling or other relevant fittings in a straight run of 8m or more and sliding saddles or clips to fit.

8.5.1.26 Boxes for the suspension of luminaires or other equipment, where considerable heat will be produced, shall be fitted with steel insert clips. Plastic boxes used for suspension of luminaires or other equipment shall be suitable for the suspended load at the expected working temperature

8.5.2 Wiring installation using trunking - Steel, PVC or Plastic

General requirements

8.5.2.1 Individual pieces of trunking shall be independently supported by means of at least two fixed points per piece. On straight runs, supports for trunking must be fixed at regular intervals with maximum spacings as given in Table 8-7 and for runs with bends, supports should be fixed as near to the bend as practicable.

Table 8-7: Spacing of Supports for Cable trunking

CSA of Trunking (CSA) in mm^2	Maximum Distance between Supports (Meters)			
	Steel Trunking		Plastic/PVC Trunking	
	Horizontal	Vertical	Horizontal	Vertical
300<CSA≤700	0.75	1.00	0. 50	0.50
700<CSA≤1500	1.25	1.50	0. 50	0.50
1500<CSA≤2500	1.75	2.00	1.25	1.25
2500<CSA≤5000	3.00	3.00	1.50	2.00
5000<CSA	3.00	3.00	1.75	2.00

8.5.2.2 Care shall be taken to use trunking bends etc. which do not impose bending radii on cables less than those required by Table 8-8.

8.5.2.3 Holes in trunking shall be drilled, punched or cut by ring saw and after cutting, burrs and sharp edges on the trunking must be removed to prevent abrasion of cables.

LDS

8.5.2.4 Cables penetrating through trunking shall be protected by conduits except PVC insulated and sheathed cables if such cables form part of a surface wiring system in which case, the holes in the trunking, through which such cables penetrate, shall be fitted with suitable rubber grommets or insulated bushes as provided in clause 8.6.2.4.

Wiring installation using steel trunking

8.5.2.5 Connection between trunking and equipment shall be made by means of a standard flange coupling or an adaptor neck, fabricated or cast.

8.5.2.6 For direct attachment of trunking to electrical equipment, the cable entries shall be provided with smooth bore bushes or grommets and the return edge of the lid of the trunking must be left intact.

Wiring installation using PVC or plastic trunking

8.5.2.7 Trunking shall have covers secured by purpose-made rivets. Covers of the clip-on type is acceptable for trunking sizes up to 100mm × 100mm.

8.5.2.8 The trunking shall be fixed and supported as recommended by the manufacturer or in the normal way by screws; but the holes in the trunking shall be made oversize to allow for the movement of expansion using washers under the head of the screw that should not be tightened to its full extent.

Table 8-8: Recommended Internal Bending radius for insulated stranded copper cables

Overall Diameter of Cable, D (mm)	Minimum Internal Bending Radius	
	Non-armored	Armored
D ≤ 10mm (Not exceeding 10mm)	3D	6D
10< D ≤ 25mm (Exceeding 10mm but not exceeding 25mm)	4D	6D
D > 25mm (Exceeding 25mm)	6D	6D

8.6 Cable Installations

8.6.1 General requirements for installation of cables

8.6.1.1 All cables shall be run in a vertical or horizontal direction, where practicable, and must be secured flat on the surface of walls, columns, partitions or ceilings, etc. throughout the entire route.

8.6.1.2 Where cables run as a span between beams, trusses, etc., rigid support throughout their entire length shall be used.

8.6.1.3 Cables crossing an expansion joint shall be formed into a loop such that any movement in the joint does not stress the cables.

LDS

8.6.1.4 For cables running on surface of walls or structures:
(a) buckle clip shall only be used to fix cables having an overall diameter not exceeding 10mm.
(b) saddles and cleats may be used if the diameter of the cable exceeds 10mm.

8.6.1.5 Cable saddles and cable cleats shall be secured by fixing screws and must be provided along the entire cable route at regular intervals:
(a) with spacing between adjacent saddles or cleats not exceeding the values given in Table 8-9; and
(b) at a distance not exceeding 150mm from:
(i) a termination; and
(ii) both sides of a bend.

8.6.1.6 Where cables are installed under floors or within false ceilings:
(a) they shall normally be supported and fixed throughout their lengths to the permanent ceiling or floor and provision shall be made for access to the cable for inspection and maintenance; and
(b) if exposed to the risk of penetration by nails, screws and the like, they must be protected by:
(i) an earthed metallic sheath; or
(ii) enclosed in earthed steel conduit; or
(iii) trunking securely supported.

8.6.1.7 Where a wiring system passes through elements of building construction such as floor, walls, roofs, ceilings, partitions or cavity barriers, the openings remaining after passage of the wiring system shall be sealed according to the fire resistance requirements of appropriate standards as may be necessary.

8.6.1.8 The internal bending radii of PVC insulated stranded copper cables shall not be less than the values given in Table 8-8:

8.6.1.9 For the installation of HV cables, the manufacturer's recommendation shall be referenced and adhered to.

8.6.2 Installation of PVC insulated, PVC sheathed non-armored cable

8.6.2.1 Where protection is required for cables running up a wall from the floor, a metal channel cover shall be fixed to a minimum height of 1.5m above finished floor level.

8.6.2.2 Where cables pass through a building structure such as wall, column or floor slab, the cables shall be drawn through PVC or GI sleeves inserted into the building structure and sealed up with proper fire resisting material of the same fire resisting requirements or equivalent as may be necessary.

8.6.2.3 When cables are routed along or across steel joints, beams, stanchions, etc. they shall be enclosed in steel or rigid PVC trunking or conduit.

8.6.2.4 Subject to clause 8.5.2.4, rubber grommets or insulated bushes shall be used to protect the non-armored cables passing through a metal box or any other metal work.

LDS

8.6.2.5 Buckle clips shall be:

(a) provided along the entire cable route at regular intervals not exceeding the spacing in Table 8-9;

(b) provided at a distance not exceeding 75mm from a termination and from both sides of a bend;

(c) fixed and secured by pins with wall plug inserted to a minimum depth of 20 mm to the surface of wall, column, partition or ceiling with the head of every pin level with the surface of the clip so that no damage to the sheath of the fixed cables can occur; and every hole in the buckle clip having a fixing pin.

8.6.2.6 The neutral conductor of a twin core cable for a lighting final circuit shall be looped through an insulated connector enclosed in the molded box or pattress accommodating the switch.

8.6.2.7 For the spacing of supports for cables of overall diameter exceeding 40mm, and for single-core cables having conductors of cross-sectional area 300mm^2 and larger, the manufacturer's recommendations shall apply.

8.6.3 Installation of armored or metallic sheathed cable

8.6.3.1 Cables buried direct in ground shall be armored or metal sheathed and shall be:

(a) buried at a depth not less than 450mm; and

(b) protected by means of cable cover tiles.

Table 8-9: Spacing of Supports for Cables in accessible positions

[1]Overall diameter of cable, D (mm)	**Maximum Spacing of Clips (Meters)**					
	Non-armored rubber, PVC or lead-sheathed cables		Armored cables		Mineral insulated copper sheathed or aluminum sheathed cables	
	Horizontal[2]	**Vertical[3]**	**Horizontal[2]**	**Vertical[3]**	**Horizontal[2]**	**Vertical[3]**
D≤9	0.25	0.40			0.60	0.80
9<D≤15	0.30	0.40	0.35	0.45	0.90	1.20
15<D≤20	0.35	0.45	0.40	0.55	1,50	2.00
20<D≤40	0.40	0.55	0.45	0.60		

1. For flat cables taken as the measurement of the major axis.

2. The spacings stated for horizontal runs may be applied also to runs at an angle of more than 30° from the vertical.

3. For runs at an angle of 30° or less from the vertical, the vertical spacings are applicable.

8.6.3.2 The bottom of the cable trench shall be first covered by a layer of sand or fine soil to a depth not less than the diameter of the cable before the cables are laid.

8.6.3.3 Another layer of sand or fine soil, to a depth of 100mm over the cables, shall then be provided before the cable tiles are laid to protect the cables throughout entire route.

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8.6.3.4 Unless otherwise advised by the cable manufacturer, a tension releasing section should be provided for every 100 meters of vertical cable run.

8.6.4 Use of flexible cable and flexible cord

8.6.4.1 A flexible cord wiring system shall be installed so that excessive tensile and tensional stress to the conductors and connections are avoided.

8.6.4.2 A flexible cord shall be:

(a) of a minimum recommended size of 0.75mm²;
(b) fire resistant; and
(c) manufactured and tested in accordance with LS IEC 60227-1:2007 and BS 6500.

8.6.4.3 Where a length of flexible cord is connected to a ceiling rose or lighting fitting, care shall be taken that any hooks, clips or cleats, etc. used for support do not compress the insulation and that every part of such hook, clip or cleat, which is likely to come into contact with the flexible cord, shall be made of insulating material.

8.6.4.4 The use of portable appliances requiring supplies at voltages exceeding 250 volts shall be avoided as far as practicable, but where this practice is unavoidable every flexible cord or cable operating at a voltage exceeding 250 volts shall be effectively protected against mechanical damage.

8.6.4.5 Where a flexible cord supports or partly supports a pendant luminaire, the maximum mass supported by the cord shall not exceed the appropriate value indicated in Table 8-10, provided that the tension of the cord does not act directly on the termination to the wiring.

Table 8-10: Current-Carrying Capacity (Amperes) and supportable Mass (kg)

Conductor Cross sectional Area (mm²)	Current-carrying capacity (Amps)		Maximum mass supported by twin flexible cord (kg)
	Single-phase AC	Three-phase AC	
0.5	3	3	2
0.75	6	6	3
1	10	10	5
1.25	13	-	5
1.5	16	16	5
2.5	25	20	5
4	32	25	5

LDS

8.7 Cable Joint & Termination Connections

8.7.1 General

8.7.1.1 Every connection at a cable termination or joint shall:

(a) be mechanically and electrically sound;
(b) be protected against moisture, mechanical damage and any vibration liable to occur;
(c) not impose any appreciable mechanical strain on the fixings of the connection;
(d) not cause any harmful damage to the cable conductor;
(e) be appropriate to the size and type of conductor (material & insulation) with which they are to be used; and
(f) be suitably insulated for the voltage of the circuits in which they are situated.

8.7.1.2 Cable sockets or terminals used shall be of such a size as to contain all the strands of the conductors and that no strand of the conductor in a cable core is cut away in making a cable joint or termination.

8.7.1.3 Terminations of mineral insulated cables shall be made with proper accessories and tools as recommended by the manufacturers.

8.7.1.4 Cable glands shall securely retain without damaging the outer sheath or the armor of the cables

8.7.1.5 Joints in non-flexible cables shall be made by soldering, brazing, welding, or mechanical clamps, or be of the compression type and of such a size as to securely retain all the wires of the conductor.

8.7.1.6 Joints in flexible cable or flexible cord shall be made by using appropriate cable couplers.

8.7.1.7 Every connection and joint shall be accessible for inspection, testing and maintenance **except** for the following:

(a) a compound filled or encapsulated joint;
(b) a connection between a cold tail and a heating element (e.g., a ceiling and floor heating system, a pipe trace-heating system); and
(c) a joint made by welding, soldering, brazing or compression tool.

8.7.1.8 Cable joints of any type along cable runs in final circuits are not allowed. “Loop-in” wiring system or termination box shall be used such that the cables or conductors are properly terminated at the junction box or equipment.

8.7.1.9 The braid or other covering over the insulation shall be cut back at least 15mm from the end of the insulation and the insulation only removed to enable the conductor to enter fully into the socket or terminal.

8.7.2 Requirements for jointing and termination of cable

8.7.2.1 All joints and terminations shall be mechanically and electrically sound having adequate mechanical strength and durable electrical continuity.

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8.7.2.2 Ferrules, compression connectors and bare portions of cable core resulting from a jointing or terminating process shall be insulated with an insulating tape or heat shrinkable tubing after completion of the jointing or terminating process.

8.7.2.3 Insulating tape or heat shrinkable tubing used shall have equal or better electrical and mechanical properties than those of the original insulation removed and must be adhered securely and permanently to the cores.

8.7.2.4 The final thickness of the joint or termination shall be in smooth contour throughout the whole length of the joint or termination.

8.7.3 Straight-through joint

8.7.3.1 In a straight-through joint for copper conductors, the two conductors shall be –
(a) butted together after the strands have been soldered solid and
(b) then joined by means of a weak-back ferrule, soldered to the cores.

8.7.3.2 Soldering shall be carried out by pouring the tinman's solder over the cores and the weak-back ferrule.

8.7.3.3 In no circumstances shall direct flame from a blow lamp be used for soldering.

8.7.3.4 Prior to making a soldered joint for aluminum conductors:
(a) each conductor shall be cleaned by means of steel wool or similar abrasive and then tinned by pouring solder, especially made for use with aluminum, over the cores to be joined;
(b) both cores shall then be inserted in a weak-back aluminum ferrule which shall be closed and the two aluminum cores to be jointed may be butted together; and
(c) the soldering must be completed by pouring the solder over the ferrule, after applying a layer of flux recommended by the cable manufacturer for this purpose.

8.7.3.5 A compression joint shall be made by inserting the conductor cores to be jointed into the opposite ends of a suitable type of compression jointing tube of the correct size for the conductors.

8.7.3.6 The tube shall then be compressed onto the cores by means of a compressing tool and procedure recommended by the compression joint or cable manufacturer.

8.7.3.7 Where specialist jointing kits are used, the complete kit shall be from the same manufacturer that is specialized in manufacturing products for this purpose and the manufacturer's recommended method and procedure shall be strictly adhered to.

8.7.4 Jointing of protective conductors

8.7.4.1 Protective conductors shall be looped into earthing terminals of exposed conductive parts or extraneous conductive parts.

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8.7.4.2 Straight joints in protective conductors shall be avoided as far as practicable; but tee-joints in protective conductors are acceptable.

8.7.4.3 Protective tapes shall be jointed by:
(a) double riveting;
(b) suitable tape clamps, each provided with at least 4 screws or bolts;
(c) terminal block of suitable size; or
(d) means of exothermic or thermic welding utilizing the high temperature reaction of powdered copper oxide and aluminum, provided that the proper material and equipment are used in accordance with the manufacturer's recommended process.

8.7.5 Joints and terminations of non-armored cables

8.7.5.1 Non-armored cables terminated at a molded box or pattress, a luminaire or other fittings shall have the overall protective sheaths carried into the molded box or pattress, luminaire or other fittings for a minimum distance of 13mm.

8.7.5.2 The circuit protective conductor shall be terminated at the earthing terminal provided in the molded box or pattress housing the wiring accessories.

8.7.5.3 Where it is not required to terminate the circuit protective conductor in an accessory, the circuit protective conductor shall be coiled away from the live terminals or any bare conductors and must be insulated and sleeved with a green-and-yellow PVC sleeve.

8.7.5.4 Jointing of circuit protective conductors of non-armored cable shall be in the same manner as jointing live conductors.

8.7.6 Jointing and termination of armored cables

8.7.6.1 Cable armors shall be terminated at the armoring clamps and the inner sheath shall pass through the gland.

8.7.6.2 Earth continuity across joints of a circuit protective conductor having adequate cross-sectional area and of the same material as the phase conductors shall be installed and connected to maintain the effectiveness of the earth continuity across every cable joint of the armored cable.

8.7.6.3 PVC insulated armored cables with copper or aluminum conductors shall be terminated in a gland fitted with an amour clamp and provision made to enable a watertight seal between the gland and the inner PVC sheath.

8.7.6.4 The gland body shall be provided with an internal conical seating to receive the armor clamping cone and a clamping nut which shall secure the armor clamping cone firmly to the armor wires thus ensuring that the armor wires are tightly clamped between the armor cone and conical armor seating.

8.7.6.5 The spigot on the gland body shall be threaded to suit standard conduit accessories and a PVC shroud fitted to cover the body of the gland and the exposed armor wires.

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8.7.6.6 Terminating gland and armor clamp for cables with aluminum conductors shall be made from aluminum.

8.7.6.7 Cores shall be terminated in a hot tinned brass or copper lug, which shall be shaped to suit the sector shape of the conductor. The core shall be tinned, and then soldered into the lug.

8.7.6.8 Despite clause 8.7.6.7, a compression termination may be used in which case:
(a) the cores shall be inserted into the sleeve of an aluminum compression type cable lug; and
(b) the sleeve shall then be compressed onto the cores by means of a compressing tool in accordance with the manufacturer's recommended working tool and procedure.

8.7.6.9 Prior to connection to the terminal, the cable lug must be painted with an anti-oxidizing paste that is suitable for preventing electrolytic action due to contact between the aluminum lug and copper or brass terminal, for an indefinite period or alternatively, copper/aluminum bimetal cable lugs may be used.

8.7.7 Termination of bonding conductors

8.7.7.1 A copper connector clamp designed for the purpose shall be used to bond:
(a) the main equipotential bonding conductor to extraneous conductive parts of the non-electrical services, and
(b) supplementary bonding conductors to exposed conductive parts or extraneous conductive parts.

8.7.7.2 Prior to installation of a copper connector clamp, all contact surfaces shall be clean and free from non- conducting materials, such as grease or paint.

8.7.7.3 For steel surface conduit installations, the supplementary bonding conductors shall be terminated at the nearest conduit or conduit box forming an integral part of the conduit installation.

8.7.7.4 For concealed steel conduit installations, the supplementary bonding conductors shall be terminated at a copper earthing terminal fitted inside a metal box forming an integral part of the conduit installation.

8.7.7.5 For access to the concealed conduit, an arrangement like a telephone cord outlet is acceptable.

8.7.8 Boxes for cable joint and cable termination

8.7.8.1 Boxes for the termination and for joining of cables may be of cast iron, or plastic shell with compound filled, or termination box and of adequate size as to contain all the strands of the conductors.

8.7.8.2 Where hot compound filling is used, the box shall be warmed thoroughly before the compound is poured to allow total adhesion between the compound and the box. The compound shall then be allowed to cool and be topped up before the box is closed ensuring that no formation of any air pockets is allowed inside the box.

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8.7.8.3 Where cold compound with plastic shell is used, the complete jointing kit, including plastic shell, compound, insulating tape etc. must be from the same proprietary manufacturer with strict adherence to recommended manufacturer's procedure.

8.7.8.4 Where the box is of cast iron, it shall be fitted with suitable armoring clamps and glands and where the box is of plastic shell, it must be fitted with suitably sized armor bond.

8.7.8.5 Where termination box is used, it shall comply with IEC 60670-1 or equivalent standard and the cables shall be terminated with fix-mounted terminal blocks complying with IEC 60947-7 series.

8.7.9 Joint and termination for high voltage cables

8.7.9.1 Joint and cable termination for HV cables shall be carried out in accordance with the manufacturer's recommendation.

8.8 Accessories

8.8.1 General

8.8.1.1 Every accessory shall be of such size that its current rating is not less than the maximum current which will normally flow through it.

8.8.1.2 Subject to clause 8.8.1.1, the maximum current of an electric motor shall be deemed to be that corresponding to its full load rating.

8.8.2 Ceiling rose

8.8.2.1 Ceiling roses shall be of best quality white bakelite in accordance with LS IEC 60423.

8.8.2.2 A ceiling rose shall not be used on a circuit having voltage normally exceeding 250 volts.

8.8.2.3 A ceiling rose shall not be used for the attachment of more than one outgoing flexible cord unless it is specially designed for multiple pendants.

8.8.3 Lamp/lighting fittings

8.8.3.1 Every lamp holder shall be of the "bayonet cap" LS IEC 61184 type and best quality bakelite suitably reinforced and fitted with shade carrier rings.

8.8.3.2 Batten type lamp holders shall be suitable for mounting direct on a conduit box and shall be of best quality bakelite suitably reinforced and fitted with shade carrier rings.

8.8.3.3 Lamp holders for lamps rated 200 watts and above shall be of the Edison screw type.

8.8.3.4 Lamp holders shall not be used on a circuit operating at a voltage exceeding 250

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volts.

8.8.3.5 Lighting fittings shall be of a type suitable for the conditions in which they are to be used.

8.8.3.6 A lamp holder shall not be connected to any circuit where the rated current of the overcurrent protective device exceeds the appropriate value stated in Table 8-11.

Table 8-11: Overcurrent protection of lamp holders

Type of lamp holder			Maximum rating of over current protective device protecting the circuit (Amperes)
Bayonet (BS 5042 or EN 61184)	B15 B22	SBC BC	6 16
Edison screw	E14 E27 E40	SES ES GES	6 16 16

8.8.4 Switches, socket outlets, connectors & plugs

8.8.4.1 Unless prior approval to the contrary is obtained from an appropriate competent authority, Lighting switches shall conform to LS IEC 60669-1, 5Amp or 15Amp where necessary for:

(a) AC circuits – insulated pattern, single pole, quick make and slow break type and

(b) DC circuits – quick make and quick break type,

8.8.4.2 Ceiling switches shall be complete with pull cords and suitable for mounting direct on a conduit box.

8.8.4.3 At all times, the successful action of switches shall not depend wholly upon spring action.

8.8.4.4 A socket outlet plug shall not be used to carry a current greater than that *for* which it is rated.

8.8.4.5 A single-phase socket outlet shall be 3-pin rectangular and shuttered as prescribed in the LS IEC 60884-2-5 or BS 2814, (1363-2)1957, with boxes conforming to LS IEC 60669-1 with unstitched outlets, unless instructed otherwise by the appropriate competent authority.

8.8.4.6 A 3- phase socket outlet and 3-phase with neutral outlet shall be of the 4-pin or 5-pin scraping earth pattern respectively.

8.8.4.7 Socket outlets shall be of switched type unless prior approval to the contrary is obtained from the appropriate competent authority.

8.8.4.8 The third pin of every 1-phase socket outlet shall be effectively earthed.

8.8.4.9 Every plug and socket outlet shall comply with the following requirements and, in addition, comply with the appropriate requirements of codes 8.8.4 and 8.8.5**:**

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(a) except for SELV circuits, it shall not be possible for any pin of a plug to make contact with any live contact of its associated socket outlet while any other pin of the plug is completely exposed; and
(b) it shall not be possible for any pin of a plug to make contact with any live contact of any socket outlet within the same installation other than the type of socket outlet for which the plug is designed.

8.8.4.10 Except where clause 8.8.4.12 applies, in a low voltage circuit every plug and socket outlet shall conform with the applicable standard listed in Table 8-12.

8.8.4.11 Every socket outlet for household and similar use shall be of the shuttered type.

8.8.4.12 A plug and socket outlet that does not comply with the standards listed in Table 8-12, may be used in a 1-phase AC or 2-wire DC circuit operating at a nominal voltage not exceeding 250 volts for:
(a) the connection of an electric clock, provided that the plug and socket outlet are designed specifically for that purpose, and that each plug incorporates a fuse of rating not exceeding 3 amperes complying with BS 646 or BS 1362 as appropriate.
(b) the connection of an electric shaver, provided that the socket outlet is either incorporated in a shaver supply unit complying with BS 3535 or, in a room other than a bathroom, is a type complying with BS 4573.
(c) a circuit having special characteristics such that danger would otherwise arise or it is necessary to distinguish the function of the circuit.

Table 8-12: Plugs and socket outlets for low voltage circuits

Type of plug and socket outlet	Rating		Applicable standard
	Amperes	Volts	
Fused plugs and shuttered socket outlets, 2-pole and earth, for AC	13	250	BS 1363 (fuses to BS 1362)
Plugs, fused or non-fused, and socket outlets, 2-pole and earth	2, 5, 15, 30	250	BS 546 (fuses, if any, to BS 646)
	10, 16, 32	250	LS IEC 60884-1
Plugs, 2-pole (non-rewireable only)	2.5	250	LS IEC 60884-1
Plugs, 2-pole	6	250	LS IEC 60884-1
Plugs, fused or non-fused, and socket outlets, protected type, 2-pole with earthing contact	5,15,30	250	BS 196
Plugs and socket outlets (industrial type)	16, 32, 63, 125	440	LS IEC 60309-2

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8.8.5 Installation of socket outlets

8.8.5.1 A socket outlet on a wall or similar structure shall be mounted at a height not less 0.3m above the floor or any working surface top (measured from the bottom of the socket outlet) to minimize the risk of mechanical damage to the socket outlet or to an associated plug.

8.8.5.2 A socket outlet shall be installed as far away as practicable from water tap, gas tap or cooker in order to avoid danger in relation to water splash and thermal effect.

8.8.5.3 Socket outlets installed on floor surface should be suitably protected from ingress of water and from mechanical damage.

8.8.5.4 Where portable equipment is likely to be used, provision shall be made so that the equipment can be fed from an adjacent and conveniently accessible socket outlet, taking account of the length of flexible cord normally fitted to portable appliances and luminaries.

8.8.5.5 Except for a SELV or a Class II circuit, a cable coupler shall:

(a) comply where appropriate with BS 196, LS IEC 60309-2, BS 4491 or BS 6991;
(b) be non-reversible; and
(c) have provision for the connection of a protective conductor.

8.8.5.6 A cable coupler shall be arranged so that the connector of the coupler is fitted at the end of the cable remote from the supply.

8.8.5.7 The switch controlling any single-pole type socket outlet, shall be connected in the live or phase wire.

8.8.5.8 The terminals of the socket outlet shall be connected such that the terminal marked:

- "L" shall be connected in the phase conductor or the non-earthed conductor.
- "N" shall be connected to the common return or neutral conductor.
- "E" shall be connected to the protective earth system.

8.8.5.9 The flexible cord shall be connected to the plug such that the markings in clause 8.8.5.8 are in accordance with the accepted color code prescribed in code 8.3.2.

8.8.6 Distribution between buildings

8.8.6.1 When it is necessary to extend a consumer's installation from the main supply point to one or more separate buildings or other points of utilization, the distribution wiring shall make use of one or more of the following systems:

(a) Armored underground cable of approved type with cable installed at a minimum depth of 500mm.
(b) Insulated cable supported on insulators (e.g., won piece/shackle) on each building with:
    (i) the maximum span of 50m between the supports, and

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(ii) a minimum ground clearance as appropriate or applicable from Schedule 1.

(c) Insulated and sheathed, UV and moisture resistant cable supported by clips and/or cleats in an approved manner on the buildings.

(d) Insulated conductors laid in suitably drained single length of galvanized conduit where the maximum distance between the buildings does not exceed 3 meters.

8.8.6.2 In all the cases of clause 8.8.6.1 the cables shall be so fixed that they:

(a) normally cannot be touched by any person, nor be liable to mechanical damage of any kind; and

(b) comply with the Liberia Electricity Distribution Code and the service provider's Sub-transmission and Distribution Construction Standards as may be applicable.

8.9 Adverse Conditions Installation

8.9.1 General

8.9.1.1 Subject to clause 3.1.3.10, Table 8-13 provides a concise list of external influences that can affect electrical installations.

8.9.2 Presence of water (AD) or high humidity (AB)

Selection Precautions

8.9.2.1 A wiring system shall be selected and erected so that no damage is caused by high humidity, high condensation or ingress of water during installation, use and maintenance.

8.9.2.2 Where water may collect or condensation may form in a wiring system, provision shall be made for its harmless escape through suitably located drainage points.

8.9.2.3 Where a wiring system may be subjected to waves (AD6), protection against mechanical damage shall be afforded by one or more of the methods given in codes 8.9.5, 8.9.6 and 8.9.7.

Conductors and enclosures of wiring installations

8.9.2.4 Copper clad aluminum conductors shall not be used in damp and high humidity conditions.

8.9.2.5 All exposed conductors and insulations at terminations and joints of cables that are insulated with impregnated paper, the ends of mineral insulated cables etc. shall be suitably sealed against ingress of moisture.

8.9.2.6 Every entry to finished ducts, ducting or trunking shall be placed to prevent the ingress of water, or be protected against such ingress.

8.9.2.7 Subject to code 8.9.4, all metal sheath and armor of cables, metal conduits, ducts, ducting, trunking, clips and their fixings, shall be of corrosion resisting material or

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finish and must not be placed in direct contact with other dissimilar metals which they are likely to set up electrolytic action.

8.9.2.8 In damp situations, enclosures for cores of sheathed cables from which the sheath has been removed and for non-sheathed cables at terminations of conduit, duct, ducting or trunking systems, shall be damp proof and corrosion resistant.

8.9.2.9 Metallic sheaths, conduits etc. in installations underwater or likely to be underwater shall not be relied upon as the only protective conductor and a separate copper protective conductor must be considered.

Switches and socket outlets

8.9.2.10 Switches having watertight enclosures with minimum IP54 or equivalent are acceptable for an installation exposed to weather.

8.9.2.11 Socket outlets acceptable for an installation exposed to weather shall:

(a) comply with IEC 60309-2 or equivalent

(b) be provided with a push-on cap and cap retaining ring or a screw-on cap with rubber gasket and

(c) have a degree of protection of at least IPX4 or equivalent.

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Table 8-13: List of External Influences (Extracted from BS 7671: 2018)

AA Temperature (°C) AA1–- 60°C + 5°C AA2–- 40°C + 5°C AA3–- 25°C + 5°C AA4 - 5 °C + 40°C AA5 + 5 °C + 40°C AA6 – 5 °C + 60°C AA7 – 25°C + 55°C AA8 - 50°C + 40°C **AB Temperature–and humidity** AB1 - 60°C – 5°C 3% 100% AB2 - 40°C +–5°C 10% 100% AB3 - 25°C +–5°C 10% 100% AB4 - 5 °C + 40°C 5% 95% AB5 + 5 °C + 40°C 5% 85% AB6 + 5 °C + –0°C 10% 100% AB7 - 25°C + –5°C 10% 100% AB8 - 50°C + 40°C 15% 100% **AC Altitude (meters)** AC1 ≤2,000 meters AC2 >2,000 meters **AD Water** AD1 Negligible AD2 Drops AD3 Spray AD4 Splashes AD5 Jets AD6 Waves AD7 Immersion AD8 Submersion **AE Foreign bodies** AE1 Negligible AE2 Small AE3 Very small AE4 Light dust AE5 Moderate dust AE6 Heavy dust **AF Corrosion** AF1 Negligible AF2 Atmospheric AF3 Intermittent AF4 Continuous	**AG Impact** AG1 Low severity AG2 Medium severity AG3 High severity **AH Vibration** AH1 Low severity AH2 Medium severity AH3 High severity **AK Flora** AK1 No hazard AK2 Hazard **AL Fauna** AL1 No hazard AL2 Hazard **AM Electromagnetic, electrostatic, or ionizing influences** AM1 Harmonics, interharmonics AM2 Signaling voltages AM3 Voltage amplitude variations AM4 Voltage unbalance AM5 Power frequency variations AM6 Induced low-frequency voltages AM7 Direct current in AC Voltages AM8 Radiated magnetic field AM9 Electric fields AM21 Induced oscillatory voltages or currents AM22 Conducted unidirectional transients of the nanosecond time scale AM23 Conducted unidirectional transients of the microsecond to the millisecond time scale AM24 Conducted oscillatory transients AM25 Radiated high frequency phenomena AM31 Electrostatic discharges AM41 Ionization	**AP Seismic Effects** AP1 Negligible AP2 Low severity AP3 Medium severity AP4 High severity **AQ Lightning** AQ1 Negligible AQ2 Indirect exposure AQ3 Direct exposure **AR Movement of air** AR1 Low AR2 Medium AR3 High **AS Wind** AS1 Low AS2 Medium AS3 High
Source: Information Extracted from BS 7671: 2018		

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8.9.3 Ambient temperature (AA)

General

8.9.3.1 A wiring system shall be selected and erected so as to be suitable for the highest and lowest local ambient temperature likely to be encountered.

8.9.3.2 The components of a wiring system, including cables and wiring enclosures shall be installed or handled only at temperatures within the limits stated in the relevant product specification or as recommended by the manufacturer.

8.9.3.3 The maximum permissible operating temperature for various classes of electrical insulation shall comply with LS IEC 60085.

Conductors and cables

8.9.3.4 The type and current-carrying capacity of every conductor, cable and flexible cord, termination and joint shall be selected to be suitable for the highest operating temperature likely to occur in normal service taking into consideration any transfer of heat from any accessory, appliance or luminaire to which the conductor, cable or flexible cord is connected.

8.9.3.5 The maximum operating and ambient temperatures, in general, for various types of cable insulations are provided in Table 8-14.

8.9.3.6 Where cables are to be connected to bare conductors or busbars, it shall be verified that their type of insulation and/or sheath is suitable for the maximum operating temperature of the bare conductors or busbars.

Table 8-14: Maximum Permissible Operating/Ambient Temperatures of Common Cable Insulations

Insulation Type	Maximum Permissible Conductor Operating Temperature (°C)	Maximum Permissible Ambient Temperature (°C)
60°C rubber	60	55
85ºC Rubber	85	80
150°C rubber	150	145
General purpose PVC	70	65
Impregnated Paper[1]	80	75
Mineral-insulated:		
(a) 70°C sheath	70	65
(b)105°C sheath[2]	105	95
Thermosetting (XLPE)[3]	90	85
Glass fiber with 185°C varnish	185	175

(1) Applicable only to cables of 600/1000V voltage grade.
(2) For mineral insulated cables that are sheathed with PVC, the values for general purpose PVC are applicable. Otherwise, the values shown for mineral insulated cables relate only to terminations; elsewhere the temperature of the cable should not exceed 250°C.
(3) XLPE means cross-linked polyethylene

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Enclosures of wiring installations

8.9.3.7 The enclosures of wiring installations for conductors and cables shall be selected and installed so that they are suitable for the extremes of ambient temperature to which they are likely to be exposed in normal service.

8.9.3.8 A vertical channel, duct, ducting or trunking installation containing conductors or cables, internal barriers shall be provided between floors or at intervals of 5m whichever is the less to prevent the air at the top of the channel, duct, ducting or trunking from attaining an excessively high temperature.

External heat sources

8.9.3.9 To avoid the effects of heat from external sources including solar gain, one or more of the following methods, or an equally effective method, may be used to protect the wiring system:

(a) shielding;
(b) placing sufficiently far from the source of heat;
(c) selecting a system with due regard for the additional temperature rise which may occur; and
(d) local reinforcement or substitution of insulating material.

8.9.3.10 Parts of a cable or flexible cord within an accessory, appliance or luminaire shall be suitable for the temperatures likely to be encountered:

(a) as determined in accordance with clause 8.9.3.1; or
(b) shall be provided with additional insulation suitable for those temperatures.

8.9.4 Presence of corrosive or polluting substance (AF)

8.9.4.1 Where the presence of corrosive or polluting substances is likely to give rise to corrosion or deterioration, parts of the wiring system likely to be affected shall be suitably protected or subject to selection of parts manufactured from materials resistant to such substances.

8.9.4.2 Metals liable to initiate electrolytic action shall not be placed in contact with each other.

8.9.4.3 Suitable precautions against corrosion shall be taken for metalwork and metallic parts of wiring systems that are liable to chemical or electrolytic attack by materials of a structure with which they may come in contact including but not limited to the following:

(a) materials containing magnesium chloride which are used in the construction of floors;
(b) plaster undercoats contaminated with corrosive salts;
(c) lime, cement and plaster on unpainted walls;
(d) oak and other acidic woods; and
(e) dissimilar metals liable to set up electrolytic action.

8.9.4.4 Application of suitable coatings before erection, or prevention of contact by separation with plastics, are recognized as a suitable precaution against corrosion.

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8.9.4.5 Enclosures of the wiring installations in dusty conditions shall be built to IP5X degree of protection or equivalent such that dust cannot enter in sufficient quantity to interfere with operation of the equipment.

8.9.5 Installation exposed to fire or explosion

General

8.9.5.1 Electrical equipment and wiring systems of electrical installations exposed to potentially explosive atmospheres shall be constructed and protected to the requirements specified for hazardous areas to IEC 60079 or equivalent.

8.9.5.2 In places where inflammable or explosive dust, vapour or gas is likely to be present under normal conditions, every accessory and lighting fitting irrespective of the voltage used, shall be protected by a flameproof enclosure to prevent danger.

8.9.5.3 In locations where inflammable material is stored, accessories shall be limited as much as possible to items necessary for use in that place.

8.9.5.4 In places where petrol-driven vehicles are stored or repaired, every accessory, other than those of the portable type, unless of the flameproof type, shall be fixed at a height of at least 105m above the general floor level.

Electrical equipment selection

8.9.5.5 The type of protection of electrical equipment for achievement of safety shall be in accordance with zone of risk listed in Table 8-15.

Table 8-15: Electrical Equipment/system selection according to Zone of risk

Type of Protection	Suitable Zone for use of protection
'ia' intrinsically-safe apparatus or system 's' special protection (specifically certified for use in Zone A)	**A, B, C**
'd' flammable enclosure 'ib' intrinsically-safe apparatus or system 'p' pressurization, continuous dilution and pressurized rooms 'e' increased safety 's' special protection 'm' encapsulation	**B, C**
'N' type of protection N 'o' oil-immersion 'q' sand filling	**C**

8.9.5.6 The maximum surface temperature of the T class of an electrical equipment shall not exceed the ignition temperature of the gases or vapors involved in accordance with the established relationship shown in Table 8-16.

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8.9.5.7 Electrical equipment with the appropriate apparatus group shall be used with the following guidance:

(a) Group I: Electrical apparatus for mines susceptible to firedamp.

(b) Group II: Electrical apparatus for places with a potentially explosive atmosphere, other than mines susceptible to firedamp.

Table 8-16: Relationship between T Class and Maximum Surface Temperature

T Class	Maximum Surface Temperature (°C)
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

8.9.6 Impact (AG) & vibration (AH)

8.9.6.1 A wiring system shall be selected and erected so as to minimize mechanical damage.

8.9.6.2 For a fixed installation where an impact of medium severity (AG2) or high severity (AG3) can occur, protection may be realized by the following means:

(a) the mechanical characteristics of the wiring system, or

(b) the location selected, or

(c) the provision of additional local or general mechanical protection, or

(d) by any combination of items (a) to (c).

8.9.6.3 Where a cable is to be concealed within a wall or partition, the concealed cable shall:

(a) incorporate an earthed metallic covering which complies with the requirements of this LEWC for a protective conductor of the circuit concerned;

(b) be enclosed in conduit, trunking or ducting satisfying the requirements of this LEWC for a protective conductor; or

(c) be provided with mechanical protection sufficient to prevent penetration of the cable by nails, screws and the like.

8.9.6.4 Where PVC concealed conduit system is applied, all conduits installed and concealed inside a set of floor slabs, wall or partition for cable wiring shall have concrete, cement or plaster cover of thickness not less than 30mm to prevent penetration of the cables inside conduits by nails, screws and the like.

8.9.6.5 A wiring system supported by or fixed to a structure or equipment subject to vibration of medium severity (AH2) or high severity (AH3) shall employ cables with fixings and connections suitable for such a situation.

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8.9.7 Other mechanical stresses (AJ)

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

8.9.7.2 There shall be adequate means of access for drawing cables in or out and, if buried in the structure, a conduit or cable ducting system for each circuit must be completely erected before cables are drawn in.

8.9.7.3 The radius of every bend in a wiring system shall be such that conductors and cables do not suffer damage

8.9.7.4 A flexible wiring system shall be installed so that excessive tensile and torsional stresses to the conductors and connections are avoided.

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CODE 9: REQUIREMENTS FOR SPECIFIC INSTALLATIONS AND EQUIPMENT

9.1 Home Appliances and Installations

9.1.1 General

9.1.1.1 Adequate number of socket outlets shall be provided for supply connections to home appliances for an individual household.

9.1.1.2 The use of a radial or ring final circuit using 13A socket outlets is acceptable for supplying a single-phase home appliance having a current rating not exceeding 13A.

9.1.1.3 The use of a radial final circuit using 5A or 15A socket outlets is acceptable for supplying a single-phase home appliance having a current rating not exceeding 5A or 15A respectively.

9.1.1.4 Home appliance having a current rating exceeding 15A to be used in an installation or household where only 5A, 13A or 15A socket outlets are provided, shall be connected permanently to a separate radial final circuit (without the use of a socket/plug arrangement) and shall be controlled by a double-pole switch in a readily accessible position placed near the appliance.

9.1.2 Electrical equipment in kitchens

9.1.2.1 For a circuit arrangement using 13A socket outlets to Code 4.3, separate circuits shall be used for supply to electrical equipment in kitchen and that for luminaires.

9.1.2.2 A cooking appliance having more than one boiling or cooking surfaces and with a total current rating exceeding 15A shall be fed from an exclusive radial final circuit and controlled by a double-pole switch separate from the appliance and placed within 2m of the appliance.

9.1.2.3 The switch for the cooking appliance shall be positioned such that the user does not have to lean across the appliance to operate it.

9.1.3 Air-conditioners

9.1.3.1 A fixed air-conditioner shall be fed by separate radial final circuit controlled by a fuse or miniature circuit breaker at the distribution board.

9.1.3.2 A fixed air-conditioner having a rating not exceeding 13A for a final circuit using 13A socket outlets or 15A for a final circuit using 15A socket outlets, may be connected using a plug and socket arrangement of adequate capacity and employing a switched socket outlet for the purpose.

9.1.3.3 A fixed air-conditioner having a rating exceeding that of clause 9.1.3.2, must be connected to a terminal block adjacent to it and controlled by a double-pole switch.

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9.1.4 Electrical equipment in bathrooms

Equipment selection

9.1.4.1 **Selection of equipment** for installations or locations containing bathtubs, shower basins and their surroundings with increased risk of electric shock, shall be guided by the following provision:

(a) **Wiring systems -** Metallic conduit or metallic trunking or an exposed metallic cable sheath or an exposed earth or bonding conductor shall not be used for surface wiring systems.

(b) **Isolation and switching devices -** Every switch or other means of electrical control or adjustment shall be so situated as to be normally inaccessible to a person using a fixed bath or shower except where the following conditions exist, or apparatus are used:

(i) the insulating cords of cord-operated switches comply with IEC 60669-1 or equivalent;

(ii) mechanical actuators, with linkages incorporated insulating components of remotely operated switches;

(iii) controls and switches of water heaters and shower pumps which comply with the relevant requirements of appropriate recognized standards;

(iv) switches are supplied by SELV at a nominal voltage not exceeding 12V rms AC or DC; or

(v) a shaver supply unit complying with sub-clause (c).

(c) **Transformers -** A shaver outlet shall have an independent circuit and earthed.

(d) **Socket Outlets and plugs -** there shall be no socket outlet provision for the purpose of connecting portable equipment in a room containing a fixed bath or shower.

(e) **Luminaires -** Parts of a lamp holder installed within a distance of 2.5m from a bath or shower cubicle shall be covered in insulating materials or totally enclosed luminaries shall be used.

(f) **Other Fixed Equipment -** Stationary appliances having heating elements shall not be installed within the reach of a person using a bath or shower.

Protective measures & applications

9.1.4.2 **Protective measures and protective applications** for installations or locations containing bathtubs, shower basins and their surroundings with increased risk of electric shock, shall be guided by the following:

(a) For general protection against electric shock, an electrical equipment shall not be installed in the interior of a bathtub or shower basin.

(b) All power sources shall be installed out of the reach of any person using a bath or shower and a power source shall incorporate protection against direct contact by insulation capable of withstanding 500V AC rms for 60s.

(c) Except for SELV, all circuits supplying equipment in a room containing a fixed bath or shower shall have protective devices and earth arrangements with characteristics such that in the event of fault to earth, there shall be a disconnection within 0.4s.

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(d) All circuits supplying electrical equipment with exposed conductive parts within 2.25m height above finished floor level shall be protected by residual current device (RCD) with a residual operating current not exceeding 30mA.
(e) Supplementary equipotential bonding shall be provided simultaneously between:
    (i) accessible exposed-conductive-parts of equipment and any extraneous-conductive part in the room.
    (ii) protective conductors of all power and lighting points and all extraneous conductive parts in the room, including metal waste, water and central heating pipes, and metal baths and metal shower basins.

9.1.4.3 Protection by means of obstacles and protection by placing out of reach shall not be used or relied upon as protection against direct contact.

9.1.4.4 Protection by use of non-conducting location (or medium) and protection by means of earth-free local equipotential bonding as a protection against indirect contact shall not be used.

9.1.5 Water heaters

9.1.5.1 All water heaters shall be provided with a thermostat or cut-out to prevent a dangerous rise in temperature.

Electrode water heaters

9.1.5.2 **Electrode water heaters** shall be connected to an AC supply system only and shall be selected and erected in accordance with the appropriate requirements of this LEWC.

9.1.5.3 The AC supply to the heater shall be controlled by a linked circuit breaker that is arranged to disconnect the supply from all electrodes simultaneously and provided with an overcurrent protective device in each conductor feeding an electrode.

9.1.5.4 The earthing of the heater or boiler shall comply with the requirements of Code 7, and in addition, the shell of the heater shall be bonded to the metallic sheath and armor, if any, of the incoming supply cable. The protective conductor shall be connected to the shell of the heater and must comply with code 7.2.3.

9.1.5.5 Where an electrode water heater is directly connected to a supply at a voltage exceeding LV, the installation shall include a residual current device (RCD) arranged to disconnect the supply from the electrodes on the occurrence of a sustained earth leakage current in excess of 10-15% of the rated current of the heater under normal conditions of operation. A time delay may be incorporated in the device to prevent unnecessary operation in the event of imbalance of short duration.

9.1.5.6 Where an electrode water heater is connected to a three phase LV supply, the shell of the heater or boiler shall be connected to the neutral of the supply as well as to the earthing conductor. The current-carrying capacity of the neutral conductor must be not less than that of the largest phase conductor connected to the equipment.

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9.1.5.7 Except as provided by clause 9.1.5.8 where the supply to an electrode water heater is single phase and one electrode is connected to a neutral conductor earthed by the service provider, the shell of the water heater or boiler shall be connected to the neutral of the supply as well as to the earthing conductor.

9.1.5.8 Where the heater is not piped to a water supply or in physical contact with any earthed metal, and where the electrodes and the water in contact with the electrodes are so shielded in insulating material that they cannot be touched while the electrodes are live, a fuse in the phase conductor may be substituted for the circuit breaker required under clause 9.1.5.3 and the shell of the heater or boiler need not be connected to the neutral of the supply.

Water heaters with immersed and uninsulated heating elements

9.1.5.9 **Water heaters having immersed and uninsulated heating elements** (are not electrode heaters) connected to single phase supply shall comply with the following:

(a) All metal parts of the heater or boiler which are in contact with the water (other than the current-carrying parts) shall be solidly and metallically connected to a metal water pipe through which the water supply to the heater is provided, and that water pipe shall be connected to the main earthing terminal by a means independent of the circuit protective conductor.

(b) The heater shall be permanently connected to the electricity supply through a double pole linked switch which is either separate from and placed within easy reach of the heater or is incorporated therein and the wiring from the heater shall be directly connected to that switch without use of a plug and socket outlet; and,

(c) Where the heater or boiler is installed in a room containing a fixed bath, the switch shall also comply with code 9.1.4.

(d) Before a heater of this type is connected, the electrical professional shall confirm that no single-pole switch, non-linked circuit breaker or fuse is fitted in the neutral conductor in any part of the circuit between the heater and the origin of the installation.

Thermal storage/instantaneous water heaters

9.1.5.10 **Single phase residential thermal storage or instantaneous water heaters** not exceeding 6kW shall be connected to an individual final circuit and be controlled by a double-pole switch of adequate rating.

9.1.5.11 Where the water heater is installed in a bathroom, the double pole switch shall be installed outside the bathroom in a convenient position.

9.1.5.12 A thermal storage or instantaneous water heater exceeding 30A or having a current rating exceeding half of the maximum demand of an installation in any one phase, shall be connected to a three-phase supply except when approved by the service provider.

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9.1.6 Electrical call bells and electric clocks

9.1.6.1 An electric call bell transformer shall be:

(a) double wound; and

(b) connected using-

(i) a plug and socket arrangement;

(ii) a connection unit; or

(iii) cable coupler.

9.1.6.2 Electric call bell pushes must be wired to the secondary windings at an extra-low voltage.

9.1.6.3 Electric clocks may be connected to a lighting circuit using a connection unit or cable coupler provided that the current demand of the circuit does not exceed the rating of the overcurrent protective device.

9.1.7 Rising mains installation

9.1.7.1 A building of more than four floors including the ground floor shall be provided with 3-phase electrical rising mains with a 3-phase 4-wire tee-off at each floor unless otherwise agreed by the service provider.

9.1.7.2 The design of the rising mains installation shall be agreed by the service provider.

9.1.7.3 Separate riser earthing conductors shall be provided to earth all units therein. The minimum cross-sectional area of riser earthing conductor shall be 70 mm^2 for copper.

9.1.7.4 The consumer's main connection between the service provider's meter and the consumer's main switch shall be installed and maintained by the consumer and shall be not less than 10mm^2 stranded copper conductor or 16mm^2 aluminum conductor or as directed by the service provider.

9.1.7.5 In multi-consumer premises a device capable of both isolating and switching the full load current of the whole installation shall be provided for each consumer at a position immediately before the service provider's meter. For a single-phase installation this isolating device shall be of double-pole type interrupting all live conductors.

9.1.7.6 In multi-consumer premises no part of the communal installation shall pass through any individual consumer's unit within the building

9.2 Busbar Trunking Distribution System

9.2.1 General

9.2.1.1 A busbar trunking system:

(a) shall comply with IEC 61439-6;

(b) must be firmly supported in place; and

(c) must be suitable for branch circuit connections to the busbars by using tap-off units or cable clamping devices.

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9.2.1.2 The cross-sectional area of phase and neutral conductors of the busbars system shall be selected considering the effects of harmonic current that may be present in the distribution system.

9.2.2 Busbar casing

9.2.2.1 The casing of the busbar trunking system shall be totally enclosed.

9.2.2.2 The busbar casing must be rigidly constructed from sheet steel, galvanized or suitably protected against corrosion of:

(a) not less than 1.2mm thick for a width or height of casing not exceeding 100mm; and

(b) not less than 1.5mm thick for a width or height of casing exceeding 100mm.

9.2.2.3 Facilities shall be incorporated in the busbar casing to provide access to the busbars at regular intervals throughout the entire length and be such that removal of the cover to access a facility shall necessitate the use of tools.

9.2.3 Busbar

9.2.3.1 For a busbar installation having rated capacity not exceeding 400A in each phase of a 3-phase 4-wire system, the associated neutral busbars shall have a cross-sectional area not less than the cross-sectional area of the phase busbar.

9.2.3.2 For busbar installation having a rated capacity exceeding 400A in each phase of a 3-phase 4-wire system, the associated neutral busbar may have a cross-sectional area smaller than the cross-sectional area of the phase busbar, if an appropriate overcurrent detection device is provided for the neutral conductor.

9.2.3.3 Where the overcurrent detection device in clause 9.2.3.2 is provided, it shall cause the disconnection of the phase conductors but not necessarily the neutral conductor.

9.2.3.4 The joint part of the busbar or the contact parts of busbars (in the case of plug-in busbar trunking systems) shall be electroplated with tin or other equivalent materials.

9.2.3.5 Drilling of all-insulated busbars for connection of cables is not acceptable.

9.2.4 Expansion, feeder and tap units

9.2.4.1 A proper expansion unit shall be provided where:

(a) both ends of the busbar trunking system are fixed;

(b) the busbar trunking system is installed across a building expansion joint; or

(c) the run of busbar exceeds 30 meters or as recommended by the busbar manufacturer.

9.2.4.2 A proper feeder unit shall be provided for each busbar trunking system for connection of incoming supply.

9.2.4.3 A proper tap-off unit shall be used where a branch circuit is taking off from the busbars.

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9.2.4.4 Where protective devices are used separately for tapping-off, they shall be provided adjacent to the tapping position for protection of the branch circuits.

9.2.4.5 Where conductors are used for connection to the busbars, they shall have current rating not less than that of the tap-off units.

9.2.4.6 Where plug-in tap-off units are used, mechanical interlocks must be provided such that the tap-off unit cannot be inserted or removed from the busbar trunking unless it is in the **'OFF'** position.

9.2.4.7 Where cut-out fuses are used for tap-off supply from busbars, they shall be equipped with an insulated carrier to avoid danger during replacement of withdrawal.

9.2.5 Busbar trunking accessories

9.2.5.1 Accessories such as bends, tees, feeder and tap-off units for busbar trunking systems shall be purpose-made.

9.2.5.2 Bends, tees and intersection units shall be designed and manufactured to suit the particular type and size of busbar system.

9.2.6 Lightning protection installation

9.2.6.1 All buildings including schools, churches, mosques, halls, hospitals, theatres and homes shall be provided with a lightning protection system.

9.2.6.2 Subject to clause 7.2.1.7, lightning protection installations shall, in general, consist of copper or aluminum tapes of 20mm x 3mm section with similar clips, test clamps and copper bond earth rods which shall be mounted in the position as indicated on drawings.

9.2.6.3 Each roof-tape shall be provided with a similar copper or aluminum down-tape to the earth test position, and from the earth test position to the earth electrode in copper only.

9.2.6.4 Suitable approved arrangements shall be made for the junction of aluminum and copper tapes.

9.2.6.5 The electrode shall consist of a copper bond rod buried in the ground as close as possible to the installation to be protected.

9.2.6.6 The earth resistance of the completed system shall in no circumstances exceed 10 ohms and shall be as low as possible.

9.2.6.7 Where earth resistance cannot be obtained by means of a single earth electrode, extra rods shall be added in parallel at a distance not less than the length of the earth electrode.

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9.3 Swimming Pools

9.3.1 General

9.3.1.1 The particular requirements under this Code 9.3 provide for swimming pools, and other similar recreational areas where the risk of electric shock is increased in normal use by a reduction in body resistance and contact of the body with earth potential.

9.3.2 Pool area characteristics assessment

9.3.2.1 The areas of concern in respect of swimming pools are demarcated into the following zones for the purpose of protection for safety and as illustrated in Figures 1 and 2:

Zone A : The interior areas of the basin covered by water
Zone B : The area immediately close to Zone A
Zone C : The area remote to zone A but which forms part of the scope.

9.3.2.2 The zones are further defined by the vertical and horizontal planes for the following:

(a) Pool below ground *(Figure 9.1); and*
(b) Pool above ground *(Figure 9.2)*

9.3.3 Protection against electric shock

9.3.3.1 Protection against direct contact shall be provided by:

(a) barriers or enclosures according to the degree of protection IP2X or IPXXB; or
(b) insulation that can withstand 500V AC rms for 60 seconds.

9.3.3.2 Supplementary equipotential bonding shall be provided for all extraneous conductive parts in zones A, B and C as well as metal grids in the solid floor.

9.3.4 Application of protective measures

9.3.4.1 In zones A and B the protective measures shall be provided only by SELV at a nominal voltage not exceeding 12V AC rms or 30V ripple-free DC with the source of supply located outside zones A, B, and C.

9.3.4.2 Exceptions to the requirements in clause 9.3.4.1 are as follows:

(a) Floodlights installed shall be supplied from their own transformers or circuits with open circuit voltages less than or equal to 18V.
(b) Socket outlets installed shall be protected by residual current devices as per code 6.3.6**.**

9.3.4.3 Protective measures that shall not be applied in any of the zones of a swimming pool include protection by:

(a) means of obstacles;
(b) placing out of reach;
(c) means of a non-conducting location; and

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(d) means of earth-free local equipotential bonding.

9.3.5 Equipment selection

9.3.5.1 **Degree of Protection -** Equipment installed shall have the following minimum degrees of protection or equivalent:

(a) Zone A – IPX 8
(b) Zone B – IPX 5
(c) Zone C – IPX 2 for indoor pool
- IPX 4 for outdoor pools
- IPX 5 where water jets are likely to occur for cleaning purposes

9.3–5.2 **Wiring Systems -** Within Zones A and B,

(a) Wiring shall be allowed only for equipment located within the zones;
(b) No metallic conduit, trunking, exposed bonding or earthing conductor or an exposed metallic cable sheath shall be employed.

Figure 1

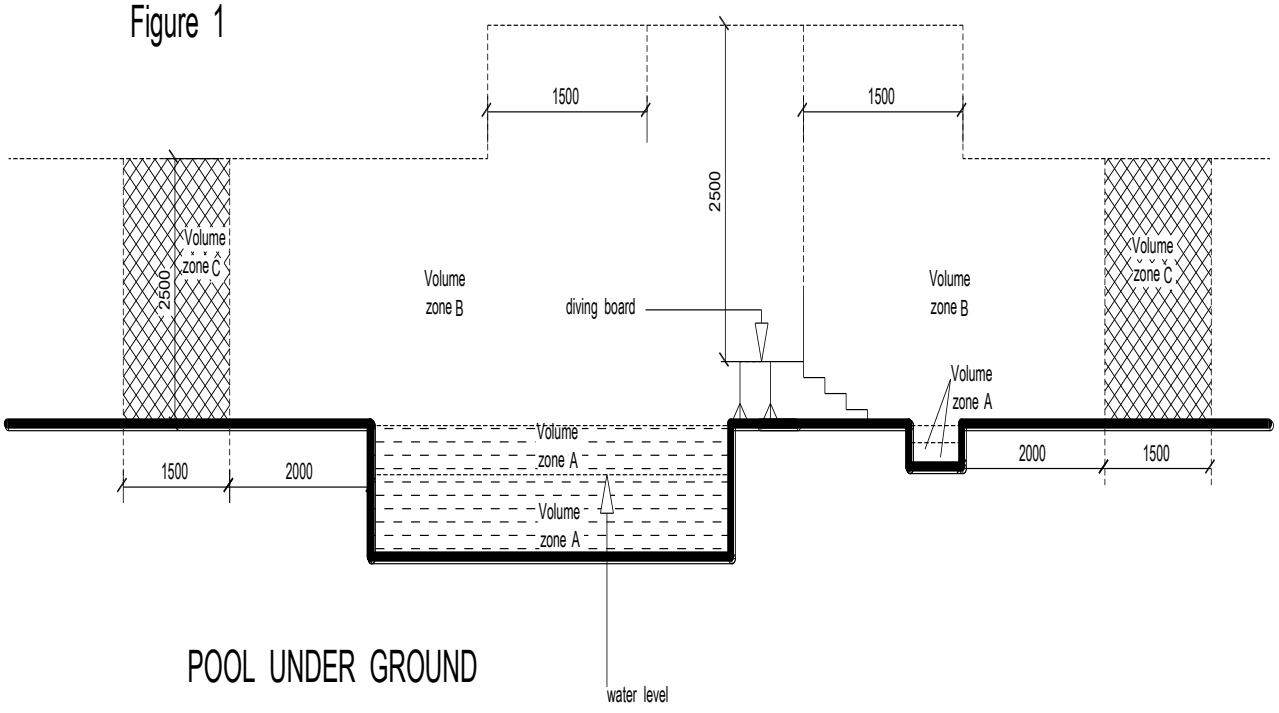

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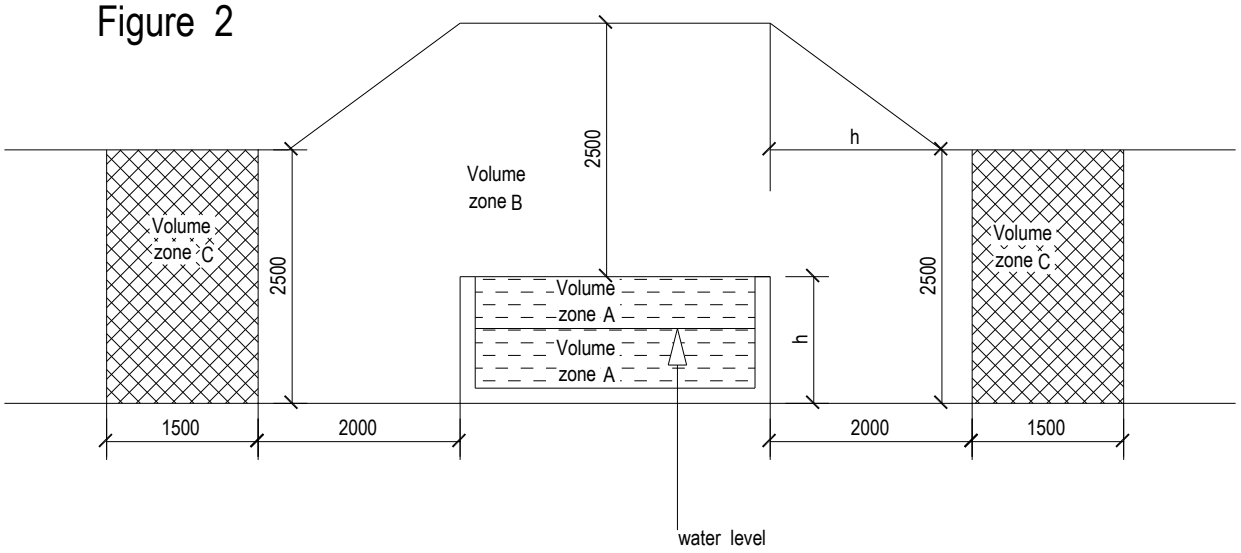
Figure 2



POOL ABOVE GROUND

Distribution and Control Gear

9.3.5.3 Within Zones A and B,

(a) No switchgear, control gear and their accessories or socket outlet shall be installed.

(b) Where a socket outlet cannot be located outside zone B the following measures shall be adopted:

(i) The socket outlet shall comply with LS IEC 60309 – 2

(ii) It shall be installed 1.25m outside zone A and 0.3m above finished floor level.

(iii) Protection shall be provided by either the use of a residual current device or by employing electrical separation (code 6.4.6) for which the safety isolating transformer is located outside Zones A, B and C.

9.3.5.4 Within Zone C, a socket outlet or a switch is permitted only if the supply circuit is protected by one of the following protective measures:

(a) SELV, the source of SELV being installed outside Zones A, B and C, however, it is permitted to install the source of SELV in Zone C if its supply circuit is protected by a RCD having the characteristics specified in code 7.1.8.

(b) Automatic disconnection of supply, using an RCD having the characteristics specified code 7.1.8.

(c) Electrical separation, the source for electrical separation supplying only one item of current-using equipment, or one socket outlet, and being installed outside Zones A, B and C; however, it is permitted to install the source in Zone C if its supply circuit is protected by a RCD having the characteristics specified in code 7.1.8.

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9.3.6 Other equipment

9.3.6.1 For zones A and B only equipment intended for use in swimming pools shall be installed.

9.3.6.2 In Zone C, equipment shall be protected by using one of the following:
(a) individually by electrical separation;
(b) SELV; or
(c) a residual current device.

9.4 Agricultural and Horticultural Premises

9.4.1 General

9.4.1.1 The requirements under this Code 9.4 provide for outdoor and indoor premises intended for the purposes of agricultural and horticultural activities where the risk of electric shock may be of serious concern.

9.4.2 Protection against both direct and indirect contact

9.4.2.1 Protection against direct contact shall be provided by at least one of the following:
(a) Barriers or enclosures to at least IP2X or IPXXB degree of protection; and
(b) Insulation capable of withstanding 500V AC rms for 60s.

9.4.2.2 Any circuit supplying a socket outlet shall be protected by a residual current device with characteristics specified in code 6.3.6.

9.4.2.3 In premises where livestock is kept, protection against indirect contact shall be provided by earthed equipotential bonding and automatic disconnection of supply specified in relation to the type of earthing system in use as provided in the subsequent clauses of codes 9.4.3 and 9.4.4 for TN and TT systems respectively.

9.4.3 TN system

9.4.3.1 The maximum disconnection times acceptable for TN Systems for various installation nominal voltages is provided in Table 9-1.

Table 9-1: Maximum disconnection times for TN systems

Nominal Voltage, U_o (volts)	Maximum disconnection time t* (seconds)
120	0.35
220 to 277	0.2
400 or 480	0.05
580	0.02

9.4.3.2 Where the disconnection time specified cannot be guaranteed it may be necessary to take other protection measures, such as supplementary equipotential bonding.

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9.4.3.3 Where fuses are used to protect socket outlets, the maximum values of earth fault loop impedance (Zs) corresponding to a disconnection time of 0.2s are as stated in Table 9-2 for a nominal voltage to Earth (U_o) of 230 V.

9.4.3.4 For other types and rated currents of general purpose (gG) fuses different from those mentioned in Table 9-2, reference shall be made to the appropriate Liberia standard or calculation to determine the value of I_a.

9.4.3.5 Where circuit breakers are used to protect socket outlets, the maximum values of earth fault loop impedance (Zs) shall be determined by the formula of clause 7.3.2.9.

9.4.3.6 Alternatively, for a nominal voltage to Earth (U_o) of 230 V and a disconnection time of 0.2s, the values specified in Table 9-3 for the types and ratings of circuit breakers listed may be used instead of calculation.

9.4.3.7 A disconnection time not exceeding 5s is acceptable for a distribution circuit and a final circuit supplying only stationary equipment.

9.4.3.8 In code 7.3.2, the formula is replaced by:

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

9.4.4 TT systems

9.4.4.1 For installations which are part of a TT system, the formula in code 7.3.3 is replaced by:

$$R_A I_a \leq 25V$$

9.4.5 Supplementary equipotential bonding

9.4.5.1 Supplementary bonding shall connect all exposed and extraneous conductive parts which can be touched by livestock.

9.4.5.2 Subject to clause 6.4.4.2, the formula shall be replaced by:

$$R \leq 25V/I_a$$

9.4.6 Protection against fire and thermal effects

9.4.6.1 For protection against fire, a residual current device having a rating of not more than 50mA shall be installed as protection for the supply to the equipment other than that essential to the welfare of livestock

9.4.6.2 Heating appliances shall be kept at an appropriate distance from livestock and combustible material to minimize risk of fire or risk of burns to livestock.

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Table 9-2: Maximum earth fault loop impedance (Zs) for fuses, for 0.2s disconnection time with Uo of 230 V

(a) General purpose (gG) fuses to BS 88 Parts 2 and 6

Rating (amperes)	6	10	16	20	25	32	40	50
Zs (ohms)	7.74	4.71	2.53	1.60	1.33	0.92	0.71	0.53

(b) Fuses to BS 1361

Rating (amperes)	5	15	20	30	45
Zs (ohms)	9.60	3.0	1.55	1.0	0.51

(c) Fuses to BS 3036

Rating (amperes)	5	15	20	30	45
Zs (ohms)	7.5	1.92	1.33	0.80	0.41

(d) Fuse to BS 1362

Rating (amperes)	13
Zs (ohms)	2.14

Note: The circuit loop impedance given in the table must not be exceeded when the conductors are at their normal operating temperatures. If the conductors are at a different temperature when tested, the reading must be adjusted accordingly.

Table 9-3: Maximum earth fault loop impedance (Zs) for circuit-breakers, for disconnection times of both 0.2s with Uo of 230 V

(a) Type 1 miniature circuit-breakers to BS 3871

Rating (amperes)	5	6	10	15	16	20	30	32	40	45	50	63	In
Zs (ohms)	12. 0		6.00		3.75		2.00		1.50		1.20		60/In
		10.0		4.00		3.00		1.88		1.33		0.95	

(b) Type 2 miniature circuit-breakers to BS 3871

Rating (amperes)	5	6	10	15	16	20	30	32	40	45	50	63	In
Zs (ohms)	6.68		3.43		2.14		1.14		0.86		0.69		34.3/In
		5.71		2.29		1.71		1.07		0.76		0.54	

(c) Type B circuit-breakers to BS EN 60898

Rating (amperes)	6	10	16	20	32	40	45	50	63	In
Zs (ohms)	8.00		3.00		1.50		1.07		0.76	48/In
		4.80		2.40		1.20		0.96		

(d) Type 3 miniature circuit-breakers to BS 3871 and Type C circuit-breakers to BS EN 60898

Rating (amperes)	5	6	10	15	16	20	30	32	40	45	50	63	In
Zs (ohms)	4.80		2.40		1.50		0.80		0.60		0.48		24/In
		4.00		1.60		1.20		0.75		0.53		0.38	

NOTE: The circuit loop impedances given in the table should not be exceeded when the conductors are at their normal operating temperature. If the conductors are at a different temperature when tested, the reading should be adjusted accordingly.

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9.4.7 Equipment selection and erection

9.4.7.1 Electrical equipment for normal use shall have at least IP44 degree of protection.

9.4.7.2 A device for emergency switching shall be installed at a location where it is inaccessible to livestock and will not be impeded by livestock and considering conditions likely to arise in the event of panic by livestock.

Electric Fence Controllers

9.4.7.3 A mains operated electric fence controller shall comply and be installed in accordance with BS EN 61011 and BS EN 61011 or LS equivalent and account shall be taken of the effects of induction when in the vicinity of overhead power lines.

9.4.7.4 A mains-operated fence controller shall not be fixed to any supporting pole of an overhead power or telecommunication line.

9.4.7.5 Despite clause 9.4.7.4, where a low voltage supply to an electric fence controller is carried by an insulated overhead line from a distribution board, the controller may be fixed to the pole carrying the supply.

9.4.7.6 Every earth electrode which is connected to the earthling terminal of an electric fence controller shall be separate from the earthling system of any other circuit and shall be situated outside the resistance area of any electrode used for protective earthing.

9.4.7.7 Not more than one controller shall be connected to each electric fence or similar system of conductors.

9.4.7.8 Every electric fence or similar system of conductors and the associated controller shall be so installed that it is not liable to come into contact with any other equipment or conductor.

9.5 Restrictive Conductive Locations

9.5.1 General

9.5.1.1 The requirements of this Code 9.5 shall apply to installations within or intended to supply equipment or appliances to be used within a location that is conducting and in which freedom of movement is restricted.

9.5.2 Protection against direct and indirect contact

9.5.2.1 Protection against direct contact shall be provided only by:

(a) a barrier or enclosure affording at least IP2X or IPXXB degree of protection or equivalent; or

(b) insulation capable of withstanding a test voltage of 500V AC rms for 60 seconds

9.5.2.2 Protection by obstacles or placing out of reach is not permitted.

9.5.2.3 Protection against indirect contact (or fault protection) shall be provided by one of the following:

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(a) automatic disconnection in accordance with code 6.4.3;
(b) electrical separation [code 6.4.6] in which case only one socket or piece of equipment shall be connected to each secondary winding of the isolating transformer; or
(c) the use of Class II equipment adequately protected to an IP code in which case the circuit shall be further protected by a residual current device having the characteristics specified in code 6.4.5.

9.5.2.4 A supply to or a socket intended to supply a hand lamp or hand-held tool shall be protected by SELV or electrical separation.

9.5.2.5 If a functional earth is required for certain equipment, for example measurement or control apparatus, equipotential bonding shall be provided between all exposed-conductive parts, all extraneous-conductive parts inside the restrictive conductive location, and the functional earth.

9.5.2.6 A supply to fixed equipment shall be protected by one of the methods listed in Clause 9.5.2.3.

9.5.2.7 All sources of supply shall be situated outside the restrictive conductive location, unless it is part of a fixed installation which complies with clause 9.5.2.3 within a permanent restrictive conductive location.

9.6 Highway Power Supplies and Street Furniture

9.6.1 General

9.6.1.1 This Code 9.6 shall apply to installations comprising road distribution circuits, street furniture such as road signs, streetlights, etc. and equipment located on roads, paths and public passages other than a part of a building.

9.6.2 Protection against electric shock

9.6.2.1 Where a measure for protection against **direct contact** is used then the means of protection shall be in accordance with the following;
(a) Code 6.3 excepting protection by obstacles (code 6.3.4);
(b) placing out of reach for low voltage overhead lines only, constructed to the standard required by electricity service provider; and
(c) other means except placing out of reach for the maintenance of street-located equipment or street furniture by skilled persons specially trained.

9.6.2.2 A door in street furniture or street located equipment used for access to electrical equipment shall not be used as a barrier or an enclosure. To satisfy the purposes of protection against direct contact the requirements of clause 6.3.3.5 shall be applied.

9.6.2.3 Protection against **indirect contact** shall be done in accordance with Code 6.4 by:
(a) Earthed equipotential bonding and automatic disconnection of supply (code 6.4.3); or
(b) Class II equipment or by equivalent insulation (code 6.4.5).

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9.6.2.4 A maximum disconnection time of 5s shall apply to all circuits feeding fixed equipment used in highway power supplies.

9.6.2.5 Where protection against indirect contact is provided by using earthed equipotential bonding and automatic disconnection, metallic structures which are not part of the street furniture or street-located equipment or connected to it shall not be connected to the main earthing terminal as extraneous conductive parts.

9.6.3 Devices for isolation and switching

9.6.3.1 Where isolation and switching are to be carried out only by qualified persons, the means of isolation shall be provided by a suitably rated fuse-carrier.

9.6.3.2 Where the service provider's cut-out is used as the means of isolation of a highway power supply the approval of the service provider shall be obtained.

9.6.4 Identification of electrical installation

9.6.4.1 On completion of highway distribution circuits and highway power supplies, detailed records as specified in clause 7.1.4.1 shall be provided with the Electrical Installation Certificate required by code 12.5.2.

9.6.4.2 Installation of underground cables for highway power supply shall be guided as follows:

(a) A buried cable in the ground shall be of insulated concentric construction or shall incorporate an earthed armor or metal sheath or both.

(b) Buried cables, conduits and ducts shall be at a sufficient depth to prevent damage by ground disturbance.

(c) Cable tiles, ducts and marking tapes used with cables shall be suitably color coded or marked for identification purposes and shall be distinct from other services.

9.6.4.3 A highway power supply installation shall be subject to programmed inspection and testing procedure.

9.7 Electric Discharge Lighting Circuits (EDL)

9.7.1 Requirement of circuits

9.7.1.1 An EDL installation shall not be connected to the electricity supply through a plug and socket arrangement.

9.7.1.2 An EDL circuit shall be capable of carrying the total steady current made up of requirements for:

(a) the lamp(s),

(b) any associated gear, and

(c) associated harmonic currents.

9.7.1.3 Where a switch is used to control filament lighting and a discharge lighting, the switch shall be designed to have a current rating of not less than the sum of the current flowing in the filament lamps and twice the total steady current flowing in

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the electric discharge lamps.

9.7.1.4 Where exact information is not available for the associated gear, the demand for the installation in volt-amperes may be taken as the lamp rating in watts multiplied by a factor of not less than 1.8.

9.7.1.5 Every switch for an EDL circuit shall be identified with a permanent label.

9.7.1.6 The cross-sectional area of the neutral conductor in an EDL circuit shall not be less than that of the phase conductor(s).

9.7.2 Means of isolation

9.7.2.1 One or more of the following means shall be provided inside the building for isolation of the supply from all live conductors to self-contained luminaires or every circuit supplying EDL luminaires:

(a) an interlock on the self-contained luminaire, so arranged that before access can be made to live parts, the supply is automatically disconnected, such means being additional to the switch normally used for controlling the circuit; or

(b) a switch having a lock or removable handle, or a distribution board which can be locked, and with such arrangements to prevent the restoration of the supply by unauthorized persons.

9.7.2.2 A fireman's emergency switch complying with code 5.2.4 shall be provided for every exterior or interior EDL installation which is operated unattended.

9.7.2.3 The firemen's emergency switch shall:

(a) be arranged to isolate the installation from all live conductors of the supply, except that it need not isolate the neutral conductor of a 3-phase 4-wire supply;

(b) for exterior installation:

(i) be outside the building and as near as possible vertically below the electrical discharge lamp(s), or

(ii) a notice indicating the position of the switch shall be placed directly below the electrical discharge lamp(s) and a nameplate fixed near the switch to render it clearly distinguishable;

(c) for interior installations, be near the main entrance to the building or alternatively in a position to be agreed with the service provider and the Fire Services Department.

9.7.2.4 For clarity of clause 9.7.2.3, an installation in a closed market or in an arcade is deemed to be an exterior installation and a temporary installation in a permanent building used for exhibitions is considered as an interior installation and not an exterior installation.

9.7.3 Installation

9.7.3.1 The luminous discharge tubes shall be:

(a) substantially supported at a sufficient distance from the sign face to ensure nonoccurrence of any arcing from the tube to any other portion of the sign

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under normal conditions; and

(b) be installed free from contact with inflammable material, except that rubber glands are permitted where a weatherproof construction is desirable.

9.7.3.2 Every ballast and control gear shall be installed as near as is practicable to its associated electric discharge lamp and the tubes not unduly exposed to mechanical damage.

9.7.4 Protective measures

9.7.4.1 Ancillary equipment for EDL installations including inductors, capacitors, resistors and transformers shall:

(a) either be:

(i) totally enclosed in a rigid and effectively earthed metal container (which may form part of the luminaires); or

(ii) placed in a suitably ventilated enclosure of construction material which shall be non-hygroscopic, anti-tracking, and substantially non-combustible; and

(b) be accessible only to authorized persons.

9.7.4.2 One point of the secondary winding of every transformer shall be connected to an earthing terminal on the body of the container.

9.7.4.3 Any circuit supplied from a transformer having a rated input exceeding 500 watts shall be provided with means for automatic disconnection of the supply at the supply end of the transformer in the event of a fault current exceeding 20 percent of the normal steady current in the circuit.

9.7.4.4 Exposed conductive parts and metalwork inclusive of metal frames of discharge lighting signs, as well as sheaths of cables shall be permanently connected to protective conductors and effectively earthed.

9.8 Electric Motors

9.8.1 General

9.8.1.1 An electrical motor shall be installed by an authorized electrical professional.

9.8.1.2 An earth wire, green or yellow insulated copper cable, shall be run to connect the frame of the motor to the earth termination of the controlling isolator.

9.8.1.3 Every electrical motor having a rating exceeding 0.37 kW shall be provided with control equipment incorporating a means of protection against overload in the motor.

9.8.1.4 The requirement in clause 9.8.1.3 shall not apply to motors incorporated in a current-using equipment complying with an appropriate recognized standard.

9.8.1.5 When installing welding transformers and motors rated more than 10kW, the local service provider shall be consulted.

LDS

9.8.2 Rating of circuits supplying electric motors

9.8.2.1 All equipment, including cable of every electrical part of the circuit carrying the starting, accelerating and load currents of a motor shall be suitable for a current at least equal to the full load current rating of the motor.

9.8.2.2 Where the motor is intended for intermittent duty and for frequent stopping and starting, account shall be taken of any cumulative effects of the starting or braking currents upon the temperature rise of the equipment of the circuit.

9.8.2.3 The rating of the circuit supplying a slip ring motor, or a commutator induction motor shall be suitable for the starting and load conditions of the motor.

9.8.3 Starting facilities of electric motors

9.8.3.1 The method of starting motors unless otherwise stated shall be as follows:
(a) motors up to and including 5.2kW shall be started direct on line; and
(b) motors above 5.2kW shall be started by star-delta or auto transformer.

9.8.3.2 The starting facilities of induction motors of various sizes shall restrict the starting current of the motors to maximum acceptable limits as required by the service provider.

9.8.3.3 For an LV induction motor, the choice of size for a motor and the maximum acceptable starting current shall be in accordance with Table 9-4.

Table 9-4: Motor size and maximum acceptable starting current by mode of supply

Supply Arrangement	Motor Size (M) in Kilowatt	No. of Phases	Maximum Starting Current (in Multiples of Full Load Current)
From Service provider's Overhead Line System	$M \leq 1.5$ $1.5 < M < 3.8$ $3.8 \leq M \leq 11$	1-phase 3-phase 3-phase	6 6 2.5
From Service provider's Non-overhead Line System	$M \leq 2.2$ $2.2 < M < 11$ $11 \leq M \leq 55$	1-phase 3-phase 3-phase	6 6 2.5

9.8.3.4 LV induction motors that exceed the limits stipulated in Table 9-4 shall require the service provider's approval in writing before installation.

9.8.3.5 Synchronous motors and HV motors shall only be installed by special arrangement with the service provider.

9.8.3.6 Motors may be provided with the means to prevent automatic restarting after the stoppage due to drop in voltage or failure of supply where unexpected restarting of the motor might cause danger, except where failure to start after a brief interruption is likely to cause greater danger.

LDS

9.8.3.7 The requirements of clause 9.8.3.6 do not preclude arrangements for starting a motor at intervals by an automatic control device, where other adequate precautions are taken against danger from unexpected restarting.

9.8.4 Supply connection to transformers

9.8.4.1 Where an autotransformer is connected to a circuit having a neutral conductor, the common terminal of the winding shall be connected to the neutral conductor.

9.8.4.2 Where a step-up transformer is used, a linked switch shall be provided for disconnecting the transformer from all live conductors (i.e. phase and neutral conductors) of the supply.

9.9 Temporary Installations

9.9.1 Scope

9.9.1.1 The requirements of this Code 9.9 shall apply to temporary electrical installations including those used for exhibitions, shows, stands, etc. and festive lighting.

9.9.2 General requirements

9.9.2.1 Permission shall be obtained from the Service Provider before any temporary installation is connected to the supply mains and notice must be given in writing at least three working days before the installation is required.

9.9.2.2 Every temporary installation shall comply with the LEWC, the Electrical Wiring Regulations and any other regulations made by the Service Provider.

9.9.2.3 Every temporary installation shall be in accordance with any special requirements of the Service Provider and shall be so maintained as to avoid risk of fire and shock.

9.9.2.4 Where a temporary installation is required for more than three months, it shall be examined and tested by a competent person classified as an Inspector every three months or as determined by the Service Provider and be completely over-hauled where necessary.

9.9.3 Design, selection and erection of installation

9.9.3.1 Control and protective switchgear shall be placed in closed cabinets which can only be opened using a key or a tool, except for those parts designed and intended to be operated by ordinary persons.

9.9.3.2 Armored cables or cables protected against mechanical damage shall be used whenever there is a risk of mechanical damage.

9.9.3.3 Wiring cables shall be copper and have a minimum cross-sectional area of 1.5 mm^2 and shall comply with an appropriate recognized standard for either thermoplastic or thermosetting insulated electric cables.

9.9.3.4 Flexible cords shall not be laid in the open and accessible to the public unless they are protected against mechanical damage.

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9.9.3.5 An adequate number of socket outlets shall be installed to allow user requirements to be met safely and where a floor-mounted socket outlet is installed, it shall be adequately protected from the accidental ingress of water.

9.9.4 Protection and safety

9.9.4.1 Every temporary installation shall be adequately protected against excess current and shall be controlled by a conveniently placed switch or other means whereby all wires can be and will be disconnected from the supply when not in use.

9.9.4.2 Each socket outlet circuit and all final circuits other than for emergency lighting shall be protected by a Residual Current Device (RCD) having the characteristics specified in code 7.1.8.

9.9.4.3 The total load on any final sub-circuit shall:
(a) not exceed 3,000 watts for residential applications; and
(b) be as determined and set by the Service Provider for industrial and constructional sites.

9.9.4.4 A cable intended to supply temporary structures shall be provided at its origin with a RCD having a rated residual operating current not exceeding 300 mA and this device shall:
(a) provide a delay in accordance with IEC 60947-2;
(b) be of “Type S” in accordance with IEC 61008-1; or
(c) comply with IEC 61009-1 for discrimination with RCDs protecting final circuits.

9.9.4.5 Structural metallic parts which are accessible from within the stand, container, etc. shall be bonded to the earthing terminal.

9.9.4.6 Every temporary installation shall be in the charge of a competent person, who shall accept full responsibility for the installation's use and any alterations thereto.

9.9.4.7 All overhead cables for temporary installations shall be provided with suitable barriers to prevent accidental contact by persons and moving equipment.

9.9.4.8 Where the electricity supply for the temporary electrical installation is obtained from a generator set, the TN-S earthing system shall be used

9.9.4.9 All temporary installations shall be tested before being put into use and shall comply with the regulations of the Service Provider.

9.9.5 Temporary supplies

9.9.5.1 Temporary supplies taken from street furniture shall not reduce the safety of the permanent installation and shall generally be in accordance with code 9.9.4.

9.9.5.2 On every temporary supply unit there shall be a durable label externally mounted stating the maximum sustained current to be supplied from that unit.

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9.10 Temporary Supply Installation for Construction/Demolition Sites or Repair and Testing

9.10.1 Scope

9.10.1.1 The requirements of this Code 9.10 shall apply to a temporary installation providing supplies during the execution of construction or demolition works, or for repair and testing purposes.

9.10.1.2 This type of supply installation shall not be used as a permanent supply.

9.10.2 General

9.10.2.1 A temporary installation providing supplies during the execution of construction or demolition works, or for repair and testing purposes shall comply with the requirements of this Code 9.10 and the Electrical Wiring Regulations.

9.10.2.2 Electrical apparatus and wiring installations in construction sites may be subjected to extreme abuse and therefore the equipment to be used must be capable to withstand the particular adverse conditions.

9.10.2.3 Correct installation of overhead line or underground cable system, circuit protection, and earthing arrangements shall be essential and must be carefully undertaken including frequent inspection and testing of such installations.

9.10.3 Design, selection and erection of installation

9.10.3.1 Operating voltages may be any of the following:

(a) Mains voltages –

(i) Three-phase, LV - 380 V 4-wire is the standard three phase mains supply vol–age.

(ii) Single-phase, LV - 220 V 2-wire is the standard single phase mains supply voltage.

(iii) Three-phase, HV – Service Provider must be consulted regarding the standard three phase mains supply voltage.

(b) Lighting accessible to public road work and site lighting which is connected to a mains supply system and accessible to public shall be operated at 110V obtained by use of an isolating transformer having the center tap of the secondary winding earthed so that the normal voltage of circuit to earth does not exceed 55 V.

9.10.3.2 For cable circuits,

(a) Where risk of mechanical damage is slight, the installation may be carried out using PVC insulated cable, otherwise armored cables must be used where damage is likely to occur.

(b) All cables that are likely to be frequently moved in normal use shall be flexible cables.

(c) All cables shall be suitably supported and properly fixed.

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9.10.3.3 For overhead line circuits:

(a) where carrier wire is used to support cable suspended between poles, codes 9.12.5 and 9.12.6 shall apply.
(b) cables crossing carriage ways must be supported by steel poles of suitable construction to withstand wind of rainstorm force though wooden supports of adequate strength may be permitted in other locations.
(c) minimum clearance between ground and line shall comply with code 9.12.4.
(d) where steel poles are used, installation methods shall comply with codes 9.12.2 and 9.12.6.
(e) where wooden poles are used, all stay wires must be insulated to prevent danger from leakage.
(f) a stay insulator placed at a height not less than 3.1m from ground shall be installed.

9.10.4 Protection of circuits and safety

9.10.4.1 Protection apparatus with adequate interrupting capability shall be provided for all main and sub-circuits against overcurrent and earth faults.

9.10.4.2 Discrimination between protection devices of main and sub- circuits shall be allowed where necessary.

9.10.4.3 The installation shall be provided with a RCD at main intake position to afford protection against earth leakage and the operating current of the RCD used must be such that when its value in amperes is multiplied by the earth fault loop impedance in ohms, the product does not exceed 25V.

9.10.4.4 The circuits supplying socket outlet shall be protected by RCD having a rated residual operating current not exceeding 30 mA.

9.10.4.5 An earthing conductor of size in accordance with code 7.3.5 shall connect the consumer's main earthing terminal to an effective earth electrode and in addition, the consumer shall provide a bond between service provider's metal sheath cable and the consumer's main earthing terminal in accordance with clause 7.3.6.7.

9.10.4.6 As precaution against danger:

(a) All equipment and cables exposed to weather, corrosive atmosphere or damp conditions shall be of the weatherproof type or contained in weatherproof enclosures suitable for the conditions.
(b) Socket outlets, plugs and cable couplers should comply with IEC 60309-2 with the appropriate color identification coding.
(c) Lamp holders shall be of the all-insulated pattern and capable of withstanding rough usage and handlamps made of insulated material with bulbs efficiently guarded against breakage.

9.10.4.7 Where the electricity supply is obtained from a generator set, the TN-S earthing system should be used.

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9.10.5 Inspection, testing and maintenance

9.10.5.1 An owner of the temporary installation shall ensure that the electrical equipment and apparatus are always maintained in a safe and proper working condition.

9.10.5.2 An electrical professional shall be appointed to be responsible for the safety and any alteration or extension of the installation.

9.10.5.3 The name, designation and contact telephone number of such person shall be permanently displayed close to the main switch of the installation.

9.10.5.4 A separate logbook for recording regular checks, maintenance, repair, extension and alteration shall be provided for inspection by the Chief Inspector/Supervisor or an authorized officer of service provider when required.

9.11 Installation in Other Special Structures

9.11.1 General requirements

9.11.1.1 The wiring requirements under this Code 9.11 cover special structures including mud houses, thatched-roof huts/houses, wooden booths, metallic container structures and playgrounds.

9.11.1.2 All installations in special structures shall follow the general guidelines and basic requirements provided in this Code 9.11 for wiring.

9.11.1.3 Despite clause 9.11.1.2 other methods that can be demonstrated to ensure equal or better standards of safety may be permitted by the Service Provider.

9.11.2 Mud houses

9.11.2.1 To ensure that accessories like switches, socket outlets, plugs, receptacles etc., are firmly secured in position in mud houses, the following types of arrangements are recommended:

(a) Conduit wiring with all accessories flush-mounted; or

(b) Surface wiring, with the wires recessed in the area immediately adjacent to the flush-mounted accessories; or

(c) Surface wiring mounted on a cement mixture reinforced sections of the wall to ensure that surface mounted accessories are secure.

9.11.2.2 In cases where no rigid facial arrangement exists to accept service lines directly from the ’service provider's service pole, it is recommended that a wooden pole of minimum dimensions 10cm x 10cm x 5m (approx. 4in x 4in x 14ft) be mounted in a cement concrete base just outside the wall of the mud house to support the service drop.

9.11.2.3 The mounting height of the meter and main switch shall be out of the reach of children but shall be at a height acceptable to the Service Provider.

9.11.3 Thatched-roof houses

9.11.3.1 There shall be no mounting of wires or accessories directly on any thatched roof.

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9.11.3.2 All wiring shall be kept at a minimum of 20cm from the roof because of its combustible nature.

9.11.3.3 A wooden support may be installed across the ceiling to which outlets, lights, etc. may be fastened.

9.11.3.4 Where the arrangement of thatched roof house does not provide sufficient overhang, selection of weather-proof type accessories may provide acceptable protection for external fixtures, light fittings and enclosures for the meter and main switch.

9.11.4 Wooden booths

9.11.4.1 All fittings shall be mounted at least 20cm from the metal roof to prevent premature deterioration of cables and accessories.

9.11.4.2 To ensure secure earthing, the earthing lead shall be mechanically protected by passing it through a conduit tube from the body of the booth to the point of connection to the earth electrode.

9.11.4.3 Where no rigid facial arrangement exists on the booth to accept service lines direct from the service provider's service pole, it is recommended to use the wooden pole method as described in clause 9.11.2.2.

9.11.4.4 Where overhang facilities are not provided to afford protection from the weather, all external fittings shall be of the weather-proof type.

9.11.5 Metallic containers

9.11.5.1 All wiring shall be of the surface conduit type using PVC conductor, preferably.

9.11.5.2 Despite clause 9.11.5.1, surface wiring may be permitted if wooden panels or strips are provided.

9.11.5.3 All wiring entering or leaving the container shall be protected by rigid conduit.

9.11.5.4 Apart from the circuit earthing:

(a) the body of the container shall also be earthed with a minimum of 2.5mm^2 copper conductor;

(b) the earthing lead shall be mechanically protected by passing it through a plastic tube from the body of the container to the point of connection to the earth electrode; and

(c) effective electrical earthing contact shall be provided by ensuring proper bonding at the container and the earth electrode.

9.11.5.5 Where no rigid facial arrangement exists in containers to accept service lines direct from the service provider's service pole, it is recommended to use the wooden pole method described in clause 9.11.2.2.

9.11.6 Playgrounds

9.11.6.1 All electrical installation work shall conform to the safety requirements of this Code 9.11.

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9.11.6.2 Overhead conductors shall be of the insulated type and the construction work shall meet the standards approved by the Service Provider.

9.11.6.3 All underground cables shall be properly buried to a minimum depth of 500 mm.

9.11.6.4 All exposed fittings shall be of the weatherproof type and of the appropriate class of insulation. (see BS 2754)

9.11.6.5 Wiring of temporary connections on fenced walls shall be avoided.

9.12 Overhead Line Installations

9.12.1 General

9.12.1.1 The following types of conductor/cable suspended on carrier wires are acceptable for LV overhead line installations:

(a) PVC insulated Hard-drawn copper or solid aluminum conductor,

(b) PVC sheathed armored or non-armored single or multi-core or bunched cables,

9.12.1.2 LV overhead lines of the ABC-type are acceptable, that is, with three insulated All-Aluminum (AA) phase wires wrapped around an insulated All-Aluminum-Alloy (AAA) neutral and conforming to the latest editions of the IEC standards applicable to their construction, including but not limited to the following:

(a) IEC 60104: Aluminum-magnesium-silicon alloy wire for overhead line conductors

(b) IEC 61089: Round wire concentric lay overhead electrical stranded conductors

(c) IEC 60228: Conductors of Insulated Cables

(d) IEC 60502-1: Cables for Rated Voltages of 1kV (Um=1.2kV) and 3KV (Um=3.6kV)

(e) ICEA S-76-474: Neutral-Supported Power Cable Assemblies with Weather Resistant Extruded Insulation Rated 600 Volts.

9.12.2 Installation of overhead lines

9.12.2.1 Cables for overhead lines shall be securely supported on insulators.

9.12.2.2 Despite clause 9.12.2.1, the cables may be attached to the carrier wire by self-retaining nylon fasteners of suitable size and strength, and evenly spaced at suitable intervals to prevent undue stress on the cables.

9.12.2.3 Mid-span joints in overhead lines are not acceptable.

9.12.2.4 Straight joints, when required, shall be made at the pole and must be properly designed, installed and insulated from the pole.

9.12.3 Service to building

9.12.3.1 Where overhead lines enter a building, the cables shall be taken into the building through an arrangement with sufficient size and adequate protection from mechanical damage.

9.12.3.2 A separate earthing system comprising earth electrodes, earthing conductors, earthing terminal etc. shall be provided for each building fed from an overhead line supply.

9.12.3.3 Where a building is fed by an overhead line distribution system, the service cable shall be led to the switchgear in conduit constructed in such a manner as to prevent the ingress of moisture.

9.12.4 Conductor to ground clearance

9.12.4.1 In cases where an overhead line is to be terminated onto a building and it is not possible to achieve the required height by attaching the overhead line to the roof of the building:

(a) an extension pole shall be fitted to the building, and the overhead line attached to the pole; or

(b) a service pole shall be erected adjacent to the building, and the supply cable from the pole to the building shall be adequately protected from mechanical damage; or

(c) underground armored cables may be considered with the consent of the Service Provider.

9.12.4.2 The conductor to ground clearance at any point of the span of the overhead line shall be:

(a) as provided in the Schedule 1; or

(b) the tallest height restriction where height restriction is imposed on any location.

9.12.5 Line materials and installation requirements

9.12.5.1 Poles of heights between 7 to 9 meters shall be made of steel, concrete, wood or other durable material of adequate strength and quality standards approved by the relevant Liberian Authority or electricity service provider.

9.12.5.2 Poles shall be erected in such a manner to withstand the forces acting on them due to overhead lines, carrier wires and wind etc. in accordance with the construction and installation standards of the Service Provider.

9.12.5. Stay wires shall be of stranded galvanized steel not less than seven strands each having a nominal diameter of 2mm.

9.12.5.4 Stay wires may be used:

(a) at the terminal poles or at poles where the overhead line changes direction; and

(b) where used, shall be placed in such a manner to take the pull exerted by the lines effectively.

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9.12.5.5 Stay wires shall be properly and securely terminated at each end to withstand the forces acting on the wires.

9.12.5.6 Carrier wires shall be made of a stranded galvanized steel having a nominal overall diameter not less than 4mm.

9.12.5.7 Carrier wires shall be firmly fixed to the supports provided.

9.12.6 Earthing of metallic parts and earth leakage protection

9.12.6.1 The metallic poles, the steel carrier wires and the stay wires, shall be permanently and effectively earthed at the main earthing terminals at both ends of the circuit.

9.12.6.2 To meet the requirement of clause 9.12.6.1, the steel carrier wire may be used as a protective conductor to earth the metallic poles and stay wires, provided that, the electrical continuity of the carrier wire is durably maintained throughout the entire run of the circuit.

9.12.6.3 Where an electrical installation is supplied from an overhead line system, the installation shall be protected against earth leakage by a residual current device (RCD).

9.13 Alterations and Additions

9.13.1 Requirements for alterations or additions to fixed installation

9.13.1.1 For any alteration or addition to an existing fixed installation, the electrical professional responsible for the work shall:

(a) carry out the alteration or addition in compliance with this Code 9.13 and the Electrical Wiring Regulations;

(b) verify that the alteration or addition does not impair the safety of the existing installation in any way; and

(c) verify that the color cables are installed in compliance with the requirements of Code 8.3.

9.13.1.2 For the purposes of clause 9.13.1.1, the following must be checked and ascertained by the responsible electrical professional:

(a) the total current demand for the installation after the alteration or addition shall not exceed the approved loading;

(b) the ratings and the conditions of the existing electrical equipment of the affected parts are suitable and adequate for the altered situation; and

(c) the protection for the affected parts is altered as may be necessary against:

(i) overcurrent;

(ii) earth fault currents; and

(iii) dangerous earth leakage currents.

9.13.1.3 Prior to an alteration or addition to an installation involving a rising mains, confirmation shall be secured by the owner from the Service Provider ascertaining if the new current demand of the installation after the alteration or the addition will exceed the existing approved loading or otherwise.

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9.13.2 Approval from the Service Provider

9.13.2.1 A person who wishes to have his electricity supply increased over and above the approved loading or extended beyond the premises to which the supply is originally intended, shall obtain prior approval from the service provider before any alteration or addition is carried out.

LDS

CODE 10: RENEWABLE ENERGY POWER SYSTEM INSTALLATIONS

10.1 General

10.1.1 Scope

10.1.1.1 This Code 10 of the LEWC shall guide safe installation and utilization of all renewable energy power system (REPS) installations specifically for photovoltaic power supply and wind turbine systems as an alternative source of energy.

10.1.1.2 Other REPS installations (e.g. hydroelectric, RE from waste, including landfill gas or biogas) shall be designed and installed in accordance with the relevant requirements in this Code 10 and national/international standards.

10.1.1.3 The scope of application of the provisions under this Code 10 include:

(a) grid connected REPS;

(b) 12V, 24V and 48V REPS for:

(i) mini-grids,

(ii) residential applications; and

(iii) solar home systems; and

(c) other REPS such as PV pumping systems.

10.1.2 Selection and erection of installation

10.1.2.1 The REPS installation shall be selected and erected to ensure safe operation and ease of maintenance at all times.

10.1.2.2 The REPS shall be designed and installed in accordance with the Electricity Mini Grid Code of Liberia and other international standards including the following:

(a) IEC 60364-7-712, BS 7671 or equivalent for PV power supply systems; and

(b) IEC 61400- 2 or equivalent for small wind turbines.

10.1.2.3 The REPS shall conform to the Solar Energy Products Technical Regulations, 2022 and any other regulations and guidelines developed and established by the LERC or any other competent or mandated authority in the Republic of Liberia.

10.1.2.4 A REPS with aggregated power rating greater than 200kW earmarked for connection to the main grid–

(a) shall be referred to the Service Provider on a case-by-case basis as more technical considerations for the connection may possibly be required by the Service Provider; and

(b) the final design details and grid connection arrangements shall be agreed by both the Service Provider and the owner.

10.1.2.5 Electrical equipment on the DC side of the system must be suitable for direct voltage and direct current.

10.1.2.6 PV modules or panels shall comply with:

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(a) all the standards and requirements specified in Section 11.3 of the Electricity Mini Grid Code of Liberia;
(b) IEC 61215/ BS EN 61215 and IEC 61730; or
(c) UL 1703; or
(d) equivalent.

10.1.2.7 PV string cables, PV array cables and PV DC main cables shall be selected in accordance with the standards and requirements of the MGC and erected so as to minimize the risk of earth faults and short-circuits, for example, by the use of reinforced or double- insulated cables to BS EN 50618.

10.1.2.8 Where ground mounting of the panels is necessary:
(a) there shall be solid foundations at each corner of the array with additional support as required by the design of the supporting structure;
(b) panels shall not be mounted closer than 800mm from the ground in order to avoid shading by grass and other vegetation;
(c) small arrays may be fixed to a single pole, securely buried into the ground and where necessary secured with stays; and
(d) the location of the mounting shall be safely fenced from damage caused by animals.

10.1.2.9 PV inverters shall comply with:
(a) all the standards and requirements specified in Section 11.3 of the MGC;
(b) IEC 62109/BS EN 62109;
(c) UL 1741; or
(d) equivalent.

10.1.2.10 Power frequency (50Hz) isolation transformers in compliance with IEC 61558 or equivalent shall be installed to provide simple separation between the primary side (DC side) and the secondary side (AC side) of PV power supply systems.

10.1.2.11 Where protective bonding conductors are installed, they shall be in parallel and as close as possible to the DC cables, AC cables and their accessories.

10.1.2.12 The selection and erection of equipment shall facilitate safe maintenance and must not adversely affect the provisions made by the manufacturer of the REPS equipment to enable maintenance or service work to be carried out safely.

10.1.2.13 The REPS shall incorporate appropriate protection facilities to avoid damage to the REPS caused by transient disturbances/abnormalities that would occur in the distribution system and the supply network operated by power company, such as supply interruption, voltage and frequency fluctuation, and voltage dip.

10.1.2.14 In selecting and using REPS installations to run in parallel with the system for distribution of electricity to the public, care shall be taken to avoid adverse effects to that system and to other installations in respect of power factor, voltage level, harmonic distortion, unbalance, starting, synchronizing and voltage fluctuation.

10.1.2.15 Where synchronization is necessary, the use of an automatic synchronizing system which considers frequency, phase and voltage is preferred.

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10.1.2.16 Means of automatic switching to avoid unsynchronized connection shall be provided to disconnect the REPS installation from the system for distribution of electricity to the public in the event of loss of that supply or deviation of the voltage or frequency at the supply terminals from declared values.

Batteries

10.1.2.17 In addition to provisions of Section 11.3 of the MGC, batteries shall conform to LS IEC 61427-1:2013 and be of a design suitable for PV applications with deep discharge and long cycle life.

10.1.2.18 The following are some guidelines for installation of batteries for REPS:

(a) Batteries shall be installed in enclosed equipment capable of protecting the connections or terminals against accidental short-circuiting.

(b) At least 20mm free space shall be left between the batteries, the wall, and the top of the box.

(c) Ventilation of the enclosure shall be ensured to avoid buildup of explosive gases during charging.

(d) The equipment shall be made of durable materials and if made of wood, it shall be well preserved against insects, termites, rot or acid.

(e) The equipment shall be securely fixed in position and each battery shall be marked with the date of manufacture and installation.

10.2 Protection for Safety

10.2.1 General

10.2.1.1 Safety and protective arrangements outlined in the Electricity Mini Grid Code of Liberia shall be strictly observed and adhered to.

10.2.1.2 Controllers shall be designed and installed to protect the batteries against overcharging and over-discharging.

10.2.1.3 The rated capacity of the controller shall be selected to handle the maximum short-circuit current from the PV-array and the maximum load.

10.2.1.4 The charge controllers and circuit breakers or fuses shall bear manufacturer's PV quality mark, PV GAP or any other accredited testing laboratory PV quality mark.

10.2.1.5 A warning system consisting of a light or an audible alarm providing at least three minutes' advance warning of self-disconnection shall be installed.

10.2.1.6 Where the controller is installed in a room which is not regularly used, a remote alarm shall be installed at a place where it can be easily noticed.

10.2.1.7 Essential service (ES) circuits may be provided with a switch to facilitate bypass of the over- discharge protection or to bypass the regulator completely.

10.2.1.8 Clause 10.2.1.7 notwithstanding, warning for low battery shall be included for non-essential services (NES).

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10.2.1.9 The owner's manual and markings on the bypass device shall clearly indicate the implications and potentially irreversible damage that may be caused by bypassing this protection.

10.2.2 Protection against electric shock

10.2.2.1 REPS equipment on the DC side shall be considered as energized, even when the system is disconnected from the AC side.

10.2.2.2 Warning labels complying with requirements of Code 11 of the LEWC shall be displayed at relevant electrical equipment including all junction boxes on the DC side.

10.2.2.3 For PV equipment, Class II equipment in accordance with IEC 61140 or equivalent insulation (such as use of class II DC connectors) shall preferably be adopted on the DC side for protection against electric shock.

10.2.2.4 The open-circuit voltage under standard test conditions for a PV equipment installed in building and premises for Categories 2 and 5 Dangerous Goods such as premises used for liquid petroleum gas storage and for petrol filling stations shall not exceed 120V DC in accordance with BS EN 60904-3.

10.2.3 Protection against overload on the DC side

10.2.3.1 Subject to clauses 10.2.3.2 and 10.2.3.3, DC overcurrent protection devices shall be provided for the circuits on the DC side.

10.2.3.2 Overload protection may be omitted to PV string and array cables when the continuous current-carrying capacity of the cable is equal to or greater than 1.25 times the short-circuit current under standard test conditions (Isc STC) in accordance with BS EN 60904-3 at any location.

10.2.3.3 Overload protection may be omitted to the PV main cable if the continuous current-carrying capacity is equal to or greater than 1.25 times short-circuit current under standard test conditions (Isc STC) in accordance with BS EN 60904-3 of the PV generator, which is the summation of all the PV string circuits connected under that PV main circuit.

10.2.4 Devices for isolation and switching

10.2.4.1 To allow for maintenance of the inverter:

(a) means of isolating the inverter from the DC side and AC side shall be provided; and

(b) the isolation devices shall be lockable and readily accessible for manual operation by the authorized electrical professional.

10.2.4.2 A switch-disconnector or a suitably rated circuit breaker shall be provided on the DC side of the inverter.

10.2.4.3 The DC switch- disconnector shall be rated for DC operation at the voltage and maximum current calculated for the circuit.

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10.2.4.4 The isolation devices shall completely isolate all live conductors, using double-pole or 4-pole isolators as may be necessary.

10.2.4.5 Dual power supply warning labels that comply with requirements of Code 11 of the LEWC shall be displayed at all electrical equipment with dual power supply sources.

10.2.5 Fault protection

10.2.5.1 Fault protection shall be provided for the installation in respect of each source of supply or combination of sources of supply that can operate independently of other sources or combinations of sources.

10.2.5.2 On the AC side of a REPS installation, cables shall be connected to the supply side of the overcurrent protective device for automatic disconnection of circuits supplying current-using equipment.

10.2.5.3 Where an RCD is used for providing additional protection, the type of RCD shall disconnect all live conductors in accordance with the manufacturer's recommendations.

10.2.5.4 The system shall be protected against damage due to accidental short-circuits by use of fuses or circuit breakers.

10.2.5.5 Each circuit shall be designed such that the peak demand does not exceed 80% of the rated capacity of the fuse or circuit breaker.

10.2.5.6 Required fuses and circuit breakers may be integrated in the controller box or installed separately in a fuse or distribution box positioned near the controller and battery.

10.2.5.7 Each fuse or circuit-breaker shall be clearly marked with rated capacity and for which circuit it is used.

10.3 Wiring Methods, Cables & Fixtures

10.3.1 Conduit wiring

10.3.1.1 Surface mounted conduit with single wire conductors shall be installed using saddles or supports at suitable intervals.

10.3.1.2 PVC conduit may be used under floors, but steel conduit shall be used in all places where heavy or unpredictable loads may occur.

10.3.1.3 Under floor conduit shall not be less than 20mm diameter to allow for subsequent maintenance.

10.3.2 Conductor cross-sectional area and voltage drop

10.3.2.1 The cross-sectional area of the conductors shall be according to the current edition of the IEE Wiring Regulations.

10.3.2.2 The rated current-carrying capacity at 35°C shall not be exceeded for any given wire cross-sectional area.

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10.3.2.3 Wires of a cross sectional area less than 2.5mm^2 shall not be used with photovoltaic systems.

10.3.2.4 The voltage across any appliance shall not be less than 5% of the battery terminal voltage and a voltage of less than 10.5V shall not be permissible across an appliance.

10.3.2.5 Voltage drop between the PV panels and batteries shall not exceed 1.0V or 5% measured at maximum charging current and the voltage drop measurements shall include any series or protection diodes.

10.3.3 Use of existing 240V AC wiring

10.3.3.1 Existing 240V AC wiring shall be used, provided it complies with the requirements under this LEWC.

10.3.4 Cable connections

10.3.4.1 Cables may be connected using junction boxes, block connectors or soldering joints with insulating sleeves.

10.3.2.2 The rated capacity through the joints shall not be less than that for the circuit to which they form a part of.

10.3.5 Power intake for underground and overhead cables

10.3.5.1 Underground cables shall be at least 600mm below the surface and shall be indicated with markers in colored plastic tape, minimum 50mm wide or a lining with bricks or slates (slabs), placed at 200mm above the cable.

10.3.5.2 Underground cables shall be used across all areas with vehicular traffic and may also be used for aesthetic reasons or to achieve a short cable run.

10.3.5.3 The cables designed for this type of application and conduits shall be able to withstand vertical loads where heavy vehicles are expected to cross the area.

10.3.5.4 Suspended cables shall be mounted so that the lowest point is at least 2700mm above ground level.

10.3.5.5 The cables shall be held in position by suitable brackets and strain relief to prevent mechanical wear and stress of the electrical connections.

10.3.5.6 Cables for outdoor exposed usage, shall be fully ultra violet resistant.

10.3.5.7 Attachment of cables or conduit to concrete, bricks or mortar or walls shall be made with appropriate fasteners and attachment of cables to metal or similar material shall be made by use of suitable toggles.

10.3.5.8 Cables through roofing shall be contained in roof-entry boxes, which shall also form a waterproof seal to avoid leakage.

10.3.5.9 Cable holes through roofing shall be avoided where possible, but where they are used, they shall be drilled at the top of corrugations and shall be thoroughly sealed and waterproof with ultra violet resistant silicone sealant or its equivalent.

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10.3.5.10 Where wires or cables are fixed to or pass through particularly flammable materials such as thatch, they shall be shielded in non-flammable conduits.

10.3.5.11 Fittings shall be fastened to suitable supports, which may need to be provided if not already present, and a conduit or fitting shall not be attached directly to thatch, or any other non-supportive surface.

10.3.6 Light fixtures

10.3.6.1 All light fixtures shall comply with IEC 60364.

10.3.6.2 Where lamps are fitted next to thatched or flammable ceiling materials, a metal lamp fitting or a metal shield shall be used to minimize the risk of fire.

10.3.6.3 Appropriate high intensity lamp shall be used for outdoor lighting such as security and street lighting.

10.3.6.4 Lamps with enclosures or detractors shall be capable of being opened for cleaning.

10.3.7 Sockets

10.3.7.1 Where socket outlets to be connected to a REPS such as a solar PV system are designed for 12V, 24V and 48V d.c, 2-pin plugs shall be used, and it shall not be possible to reverse the polarity.

10.3.7.2 Home appliances such as radios, fans, spotlights, rechargeable torches, refrigerators and special instruments shall be connected to the REPS system through socket outlets designed for such voltage or provided with suitable and efficient adaptors or inverters.

10.3.7.3 A 12V, 24V and 48V appliance shall not have a 240V AC mains type plug attached to it.

10.3.7.4 Where 240V outlets from a DC-AC inverter is provided, mains type socket shall be used.

10.3.7.5 Circuit breakers and proper earth safety system shall be provided to prevent damage to the inverter in case of an overload.

10.3.7.6 All installations that have DC sockets shall be wired so that the large diameter pin in the plug is always positive.

10.3.7.7 All positive connections shall be made with red insulated wire and negative connections with black insulated wires. (Check with color code in the LEWC)

10.3.8 Switches

10.3.8.1 Standard switches for 240V AC shall not be used as an alternative to special switches for 12V, 24V and 48V DC except where written approval from the manufacturer and the appropriate authority is obtained indicating the acceptable DC voltage and current limits.

10.3.8.2 All switches shall be rated at twice their expected current-carrying load.

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10.3.8.3 Where particularly required, special time switches, photosensitive switches, remote and relay switches shall be specified.

10.3.8.4 All switches shall include a clear visual indication of their state.

10.3.9 Workmanship and finishing

10.3.9.1 Where detailed specifications are not provided by the client for choice of materials or workmanship, standard practice for the trade shall be followed.

10.3.9.2 Standard practice regarding the approval of quality, assessing capacity of REPS supply source (such as PV-panels, wind turbine etc), batteries, controllers and other components shall comply with Liberia Standards.

10.4 Inspection, Testing and Maintenance

10.4.1 General

10.4.1.1 An owner of the REPS installation shall ensure that the associated electrical equipment is regularly inspected and maintained in a safe and proper working condition in accordance with the manufacturer's guidelines/instructions and the relevant requirements in the LEWC.

10.4.1.2 Notice showing the name and registration number of the electrical contractor or electrical professional employed for maintaining the REPS installation shall be displayed at a prominent location.

10.4.1.3 An owner of the REPS installation shall display the REPS circuit diagrams at appropriate locations to facilitate proper shut down of the grid connection arrangement by maintenance personnel under normal and emergency operations.

10.4.1.4 For REPS installation connected in parallel with the mains supply from an service provider, special attention shall be paid to ensure that the REPS installation shall be automatically disconnected from the mains supply when the mains supply trips.

10.4.1.5 During maintenance, the power generation side, grid connection side, and battery (if applicable) of REPS shall be isolated to prevent electric shock to electrical professionals.

10.4.1.6 The requirements stated in the checklist for inspection and testing of REPS installations under Part E of the LEWC shall be followed.

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CODE 11: DISPLAY OF LABELS AND NOTICES

11.1 Warning Notices and Labels

11.1.1 General

11.1.1.1 Warning notices and labels shall be displayed on equipment and installations permanently or temporarily, prior to or during and after electrical installation works as may be required.

11.1.1.2 This Code 11 of the LEWC prescribes the form of some of the critical labels and notices that must be used in the specific cases identified as well as other prescriptions in other parts of the LEWC.

11.2 Substations and Switch Rooms

11.2.1 Warning notice for high voltage installations

11.2.1.1 Every item of equipment or enclosure within which a nominal voltage (Uo) exceeding 230 volts exists shall be so arranged that before access is gained to a live part, a warning of the maximum voltage present is clearly visible.

11.2.1.2 Means of access to all live parts of switchgear and other fixed live parts where different nominal voltages exist shall be marked to indicate the voltages present.

11.2.1.3 Form of Notices:

(a) 'DANGER – HIGH VOLTAGE' or 'DANGER XXX VOLTS': in legible letters and characters each not less than 30 mm high shall be displayed at the HV installation.

(b) 'DANGER – HIGH VOLTAGE' 'DANGER XXX VOLTS': in legible letters and characters each not less than 50 mm high shall be displayed along a cable run easily accessible by public at regular intervals of about 3m.

(c) "CAUTION-ELECTRIC CABLE BELOW": in legible letters on warning tape colored yellow or black stripes laid at regular intervals at a depth of 200mm below final grade for buried cables.

11.2.2 Warning notice for switch rooms

11.2.2.1 A notice on the door of a switch room shall either be:

(a) painted on the outside of the door of the switch room or

(b) engraved on plastic boards and permanently fixed on the outside of the door of the switch room.

11.2.2.2 Form of Notice:

'DANGER—ELECTRICITY, UNAUTHORISED ENTRY PROHIBITED': In legible letters and characters with the word 'DANGER' not less than 30mm high and each other letter and characters not less than 15mm high.

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11.2.3 Warning notice for distribution boards

11.2.3.1 A notice of durable material shall be fixed in each position (of an equipment or enclosure such as a distribution board) where there are live parts which are not capable of being isolated by a single device.

11.2.3.2 Form of Notice:

'DANGER': In red legible letters and characters each not less than 10mm high, displayed at or near each distribution board or similar equipment.

11.2.4 Warning notice for substations

11.2.4.1 A notice on the door of a substation shall either be:

(a) painted on the outside of the door of the substation or

(b) engraved on plastic boards and permanently fixed on the outside of the door of the substation.

11.2.4.2 Form of Notice:

'DANGER—SUBSTATION, UNAUTHORISED ENTRY PROHIBITED': In legible letters and characters with the word 'DANGER' not less than 30mm high and each other letters and characters not less than 15mm high.

11.3 Warning Notice for Connection of Earthing and Main Bonding Conductors

11.3.1 Earthing and bonding connections

11.3.1.1 A permanent legible label of warning notice shall be permanently fixed in a visible position at or near:

(a) the point of connection of every earthing conductor to an earth electrode;

(b) the point of connection of every bonding conductor to an extraneous-conductive part; and

(c) the main earth terminal, where separate from main switchgear.

11.3.1.2 Form of Notice:

'SAFETY ELECTRICAL EARTH CONNECTION—DO NOT REMOVE': in legible letters and characters each not less than 5mm high to be permanently fixed at locations identified in clause 11.3.1.1.

11.4 Warning Notice for Repair

11.4.1 Notice of repair and caution for men at work

11.4.1.1 Appropriate notice in forms presented in clause 11.4.1.2 shall be displayed at locations such as:

(a) on a distribution board or switch or circuit breaker controlling the circuit on which work is being carried out; and

(b) at or near any equipment where bare or live parts which are normally protected from direct contact are uncovered and exposed for work to be carried out.

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11.4.1.2 Form of Notice: (All in legible letters and characters not less than 50mm high)

(a) **'CAUTION—EQUIPMENT UNDER REPAIR'** and/or
(b) 'CAUTION—MEN AT WORK' and/or
(c) **'ELECTRICAL WORK IN PROGRESS, KEEP POWER OFF'**.

11.5 Notice for Renewable Energy Power System

11.5.1 Warning notice for REPS

11.5.1.1 The warning word 'DANGER' in white legible letters and characters not less than 10mm high, in red background shall be displayed at or near DC switchgear.

11.5.1.2 The words **'Warning-Dual Supply'** in black legible letters and characters not less than 10mm high, in yellow background shall be displayed at all electrical equipment with dual power supply.

11.5.1.3 Battery enclosures of REPS, if used, shall be provided with warning notices such as **'DANGER', 'EXPLOSIVE SMOKE', 'DO NOT SMOKE', 'NO SMOKING', 'EXPLOSIVE GAS'** or '**DO NOT USE OPEN FLAMES'**, as may be applicable.

11.5.1.4 Where remote warning is installed for REPS, labels made of permanent inerasable material with clearly legible letters and shall be displayed in a prominent position, providing an explanation of the warning signals.

11.5.2 Notice on REPS electrical professional

11.5.2.1 A notice shall be displayed at the REPS facility showing the name and registration number of the electrical contractor or electrical professional employed for maintaining the generating facility in continuous safe work order.

11.5.2.2 Form of Notice: (All in legible letters and characters not less than 5mm high)

'IMPORTANT NOTICE
This REPS installation is maintained for continuous safe work by:

Name of electrical professional or electrical contractor:
…….

Registration No.: ……

Date of Notice: .....

11.6 Notice of Periodic Inspection & Testing of Electrical Installations

11.6.1 Periodic inspection and testing

11.6.1.1 A notice of durable material shall be fixed in a prominent position at or near the installation distribution board upon completion of work carried out in accordance with Code 12.1 or Code 12.4.

11.6.1.2 Form of Notice: (Inscribed in legible letters and characters not less than 5mm high)

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'IMPORTANT NOTICE

This installation must be periodically inspected and tested by an electrical inspector and a report on its condition obtained, as Prescribed by regulation 19(5) of the Electrical Wiring Regulations

Date of last inspection.....

Recommended date of next inspection….....

11.7 Notice of Testing for Residual Current Devices (RCD)

11.7.1 Presence of RCD & testing notices

11.7.1.1 Where an installation incorporates a residual current device a notice shall be fixed in a prominent position at or near the installation distribution board.

11.7.1.2 Form of Notice: The notice shall be in legible letters and characters each not less than 5mm and shall read as follows:

'This installation, or part of it, is protected by a device which automatically switches off the supply if an earth fault develops.

Test quarterly by pressing the button marked 'T' or 'Test'. The device should switch off the supply and should then be switched on to restore the supply.

If the device does not switch off the supply when the button is pressed, seek expert advice.'

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PART E

CODE 12: INSPECTION, TESTING AND CERTIFICATION

12.1 Inspection and Testing

12.1.1 General

12.1.1.1 Every new installation or work completed after repair, alteration or addition made to an existing installation shall be inspected, tested and certified before it is energized or put into use.

12.1.1.2 The inspection, testing and certification shall be carried out by a qualified electrical professional (or electrical contractor) attesting that the electrical wiring installation is completed to the relevant design and is in compliance with the:
(a) Electrical Wiring Regulations; and
(b) Certification and Licensing of Electrical Professionals and Contractors Regulations.

12.1.1.3 Safety precautionary measures including those applicable ones stated in Code 3 shall be taken to avoid danger to persons and damage to property and installed equipment during inspection and testing, even if the circuit being tested is defective.

12.1.2 Inspection (low voltage installations)

12.1.2.1 The purpose of inspection is to verify that an installed equipment is:
(a) appropriately selected and installed in accordance with the Electrical Wiring Regulations; and
(b) not defective or visibly damaged to limit the risk of accident.

12.1.2.2 Inspection shall be conducted for that part of the installation under inspection disconnected from the supply.

12.1.2.3 Inspection shall always precede testing.

12.1.2.4 The following checklist, where applicable to the installation, shall form the basis of the visual inspection:
(a) connection of conductors;
(b) identification of conductors;
(c) routing of cables in safe zones or protected against mechanical damage;
(d) selection of conductors for current-carrying capacity and voltage drops, in accordance with the design;
(e) connection of single-pole devices for protection or switching in phase conductors only;
(f) correct connection of accessories and equipment;
(g) presence of fire barriers, suitable seals and protection against thermal effects;
(h) neatness and tidiness of connections of conductors and accessories;

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(i) methods of protection against electric shock including:
    (i) protection against both direct and indirect contacts i.e.
        - SELV
        - limitation of discharged energy
    (ii) protection against direct contact (including measurement of distances where appropriate), including protection by:
        - insulation of live parts
        - a barrier of an enclosure
        - obstacles
        - placing out of reach
        - PELV
    (iii) protection against indirect contact including:
        - earthed equipotential bonding and automatic disconnection of supply
        - presence of earthing conductor
        - presence of protective conductors
        - presence of main equipotential bonding conductors
        - presence of supplementary equipotential bonding conductors
        - use of Class II equipment or equivalent insulation
        - electrical separation;
(j) prevention of mutual detrimental influence;
(k) presence of appropriate devices for isolation and switching correctly located
(l) presence of undervoltage protective devices (where appropriate);
(m) choice and setting of protective and monitoring devices (for protection against indirect contact and/or protection against overcurrent) and assurance that integrity of protection is not jeopardized by method of installation or any possible alteration;
(n) labelling of protective devices, switches and terminals;
(o) selection of equipment and protective measures appropriate to external influences;
(p) adequacy of access to switchgear and equipment;
(q) presence of danger notices and other warning signs;
(r) presence of diagrams, instructions and similar information;
(s) erection methods; and
(t) requirements for installations in hazardous or other special locations including the following additional checks –
    - where appropriate the area involved must be checked to ensure ‘gas free’ condition before insulation and earth fault loop impedance test are carried out.
    - equipment must be kept clean and free from accumulation of dust, foreign particles and deleterious substances and equipment is kept free from condensation.
    - all lamps, fuses and replaceable parts must be checked so that correct types and rating are being used; and

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- appropriateness of surface temperature of all equipment to the type of protection provided.

12.1.3 Testing

12.1.3.1 On completion of the installation, the electrical professional or electrical contractor shall carry out the following tests as may be applicable in the presence of the authorized person:
(a) tests in accordance with LS IEC 60245-1;
(b) continuity tests on:
(i) all earth/protective conductors;
(ii) all ring final circuit conductors;
(c) insulation resistance tests between live conductors, sheathing sections and earth resistance in accordance with the procedure described in Schedule 2;
(d) polarity tests;
(e) earth electrode resistance;
(f) earth fault loop impedance;
(g) prospective fault current;
(h) phase sequence;
(i) functional testing of RCDs and RCBOs; and
(j) full load when specifically ordered.

12.1.3.2 Tests shall be carried out on each circuit in addition to the complete installation.

12.1.3.3 Where a test fails, the installation shall be corrected and the test and any preceding test, the result of which could have been influenced by the fault indicated, shall be repeated to ensure compliance.

12.2 Testing Procedures & Precautionary measures

12.2.1 Sequence of tests

12.2.1.1 Tests shall be carried out in the following sequence:
(a) Before supply is connected; followed by
(b) With the supply connected.

12.2.1.2 **Before Supply is Connected** the following tests shall be carried out in the sequence specified:
(a) continuity test of all protective conductors;
(b) continuity test of ring final circuit conductors;
(c) insulation resistance test:
(i) between live conductors, and
(ii) between each live conductor and earth;
(d) polarity test, by continuity methods; and
(e) earth electrode resistance test using an earth electrode resistance tester.

12.2.1.3 **With Supply Connected** the following tests shall be conducted in the sequence specified:
(a) recheck of polarity test;
(b) earth electrode resistance test using a loop impedance tester;

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(c) earth fault loop impedance test;
(d) prospective fault current test; and
(e) functional testing of RCDs and RCBOs.

12.2.1.4 The permitted test voltages for the various circuits and the corresponding minimum insulation resistance measurement test results as provided in Table 12-1 shall be considered satisfactory.

Table 12-1: Test Voltages & Minimum values of insulation resistance

Circuit nominal voltage (V)	Test voltage DC (V)	Minimum insulation resistance in MΩ
(a) SELV and PELV	250	0.5
(b) Up to and including 500V except for systems under (a)	500	2.0
(c) Above 500V	1000	2.0
(d) Above Low Voltage	Insulation of cables above LV shall be measured by pressure test and the values of the insulation test taken before and after the pressure test can be used as a reference.	

12.2.2 Continuity test of protective conductors

12.2.2.1 Every protective conductor, including all conductors and any extraneous conductive parts used for equipotential bonding shall be tested for continuity.

12.2.2.2 The test shall be made by connecting (together) the neutral and protective conductors at the mains position and checking between earth and neutral at every outlet by a continuity tester, which shall show a near zero reading.

12.2.2.3 If no neutral was available at the testing position, an extra conductor shall be used to extend testing probe of the continuity test for the test to be carried out.

12.2.3 Continuity test of a ring final circuit

12.2.3.1 The ring circuit shall be tested from the distribution board as follows:
(a) The ends of the two cables forming the phase conductor shall be separated, and a continuity test must show a near zero reading between the two;
(b) the same tests to be carried out between the two cables that form the neutral conductor, and between the two cables that form the protective conductor, all producing near zero readings.

12.2.3.2 The testing method in clause 12.2.3.1 is only applicable when the ring circuit has been inspected throughout prior to the test, to ascertain that no interconnection (multi-loops) exists on the ring circuit; otherwise, the testing methods stipulated in Part 3 of the Guidance Note 3 to BS7671 should be adopted instead.

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12.2.4 Insulation resistance test

12.2.4.1 A suitable DC insulation tester shall be used to measure insulation resistance and care must be taken to ensure that the insulation of the equipment under test can withstand the test voltage without damage.

12.2.4.2 The main switchboard and each distribution circuit shall be tested separately except that where a large installation is involved the circuits may be divided into sections with groups of outlets to carry out the test. e.g., a socket outlet or appliance or luminaire incorporating a switch is regarded as one outlet.

12.2.4.3 The insulation resistance to earth shall not be less than the appropriate values given in Table 12-1 when measured:

(a) with all fuse links in place, all switches and circuit breakers (including, if practicable, the main switch) closed and all poles or phases of the wiring electrically connected; and

(b) between all conductors connected to any one phase or pole of the supply and, in turn, all conductors connected to each other phase or pole

12.2.4.4 In carrying out the test:

(a) wherever practicable,

(i) all lamps shall be removed and

(ii) all current-using equipment (including load on socket outlets) shall be disconnected and

(iii) all local switches controlling lamps or other equipment shall be closed;

(b) where the removal of lamps and/or the disconnection of current-using equipment is impracticable, the local switches controlling such lamps and/or equipment shall be open;

(c) electronic devices connected in the installation shall be isolated or short-circuited where appropriate so that they are not damaged by the test voltage; and

(d) where the circuits contain voltage sensitive devices, the test shall measure the insulation resistance to earth with all live conductors (including the neutral) connected together.

12.2.4.5 Where equipment is disconnected for the test and the equipment has exposed conductive parts required to be connected to protective conductors, the insulation resistance between the exposed conductive parts and all live parts of the equipment shall be measured separately and must have a minimum insulation resistance of not less than one mega-ohm (1M**Ω)**.

12.2.5 Polarity test

12.2.5.1 A test of polarity shall be carried out to verify that:

(a) every fuse, single-pole control and protective device is connected in the phase conductor only;

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(b) center-contact bayonet and Edison-type screw lamp holder to IEC 60238 in circuits having an earthed neutral conductor, have their outer or screwed contacts connected to that neutral conductor; and
(c) wiring has been correctly connected to socket outlets and similar accessories. *(Note: Exposed conductive parts should be correctly connected to earth.)*

12.2.6 Earth electrode resistance test

12.2.6.1 A proper earth electrode resistance tester shall be used, referring to recommended manufacturer's user guides, to measure earth electrode resistance. The general procedure for measuring earth electrode resistance based on the use of auxiliary electrodes is provided in Schedule 2.

12.2.6.2 For an electrical installation having four or more earth electrodes which are installed in line and following a general direction not exceeding 15^{o} deviation and with separation between adjacent electrodes not less than the recommended distance by the manufacturer of the tester but in any case, not less than 20 meters, these electrodes can be used in turn as the auxiliary electrodes for the purpose of measuring the earth electrode resistances.

12.2.6.3 An alternative method based on the use of a loop impedance tester may be used for measuring earth electrode resistance where electricity supply is connected.

12.2.6.4 Subject to clause 12.2.6.3, a loop impedance tester shall be connected between the phase conductor at the origin of the installation and the earth electrode with the test link open, and a test performed. This impedance reading could be treated as the electrode resistance.

12.2.7 Earth fault loop impedance

12.2.7.1 Earth fault loop impedance shall be measured using a Phase-Earth Loop Tester with a scale calibrated in ohms.

12.2.7.2 The earth fault loop impedance shall not exceed the requirements of Code 7.2 and other thresholds specified in various parts of the LEWC.

12.2.7.3 Before the test begins, it shall be established by inspection that,
(a) the earthing conductor and all relevant earth connections are in place, and
(b) the bonding connection to the service provider's earthing facilities is disconnected.

12.2.7.4 Measures shall be taken during the impedance tests especially, when the earth leakage protective devices are effectively removed for the duration of the tests, to ensure that the installation is not being used other than by person(s) carrying out the tests.

12.2.8 Functions of all devices including protective devices

Functional Test of RCD

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12.2.8.1 The functioning of RCDs shall be checked by a residual current device tester by simulating an earth fault to verify its effective operation as well as testing the in-built test button for proper functioning using testing methods complying with relevant national/international standards such as IEC 61008 or IEC 61009 for general purpose RCDs or RCBOs respectively.

Other Functional tests

12.2.8.2 Functioning of the following shall be checked by hand operation:

(a) other protective devices, such as miniature circuit breakers, molded case circuit breakers (MCCB), air circuit breakers, fuse switches, switch-fuses and protective relays etc.

(b) all items of equipment such as isolators, switches and indicative devices.

Secondary Injection Test

12.2.8.3 Overload and fault current protection characteristics of protection relays shall be verified with secondary injection test involving the following procedure:

(a) injection of different magnitudes of alternating current into the relay terminals;

(b) measurement of the relay operating time; and

(c) checking the measured operating time against the manufacturer's data sheet.

12.2.8.4 The waveform and the accuracy of the alternating current injected shall be in accordance with the requirements specified by the manufacturer.

12.2.8.5 Safety precautions for work on LV specified under Code 3.3 shall be observed.

12.3 Inspection & Testing of High Voltage Installations

12.3.1 Safety during Inspection

12.3.1.1 Subject to codes 12.1.1 and 12.1.2 inspection of HV installations shall comply with additional checks on the following items where relevant:

(a) check continuity of protective conductors especially the bonding of all exposed conductive parts;

(b) provision of suitable locking facilities for every entry to an HV switch room/substation; and

(c) provision of padlock facilities for shutters, key boxes etc.

12.3.2 Testing of high voltage installations

Safety

12.3.2.1 The following additional safety precautions are required during testing of an HV installation:

(a) HV test area shall be screened or fitted with barrier with appropriate label or sign attached to avoid unauthorized access.

(b) Responsible person shall be present throughout the duration of the tests.

(c) The test area shall be continually watched while testing is in progress.

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Testing requirements

12.3.2.2 Testing of HV installations shall be conducted accordance to
(a) relevant recognized standards,
(b) manufacturers' recommendation, and
(c) operations and maintenance instructions.

12.3.2.3 Where the procedures involve sanction-for-test which requires the removal of circuit main earths,
(a) the earths (except those without lock, for example, portable earth) must be secured with working locks; and
(b) the keys to the locks shall be retained by person in-charge for removal and replacement of the earths as requested.

12.3.2.4 Live voltage and phase checking on HV equipment may only be undertaken by person in-charge with assistance, if necessary, from a person who has been specifically trained for live voltage and phase checking, acting on verbal instructions from the person in-charge.

12.4 Periodic Inspection and Testing

12.4.1 General

12.4.1.1 Periodic inspection and testing of all installations shall be mandatory and the frequency of inspection and testing shall be determined by the type of installation, its use, maintenance schedule and environmental influences.

12.4.1.2 Generally, periodic inspection and testing of installations shall be undertaken according to the following schedule:
(a) 10 years after initial installation and use; and
(b) every 3 - 5 years after 10 years of initial installation.

12.4.2 Specific requirements for fixed Installations

12.4.2.1 Despite code 12.4.1, fixed electrical installations having any approved loading at the following types of premises are required to be inspected, tested and certified at least **once every year**:
(a) Places of public entertainment;
(b) Premises for the manufacturing or storing of dangerous goods such as dangerous goods stores, dangerous goods storage tanks, gas stations, petroleum and diesel filling stations and liquefied petroleum gas stations; and
(c) High voltage fixed installations such as HV switch rooms and substations under the control of the owners, large plant and machinery etc.

12.4.2.2 Despite code 12.4.1, fixed electrical installations in factories and industrial undertakings having an approved loading exceeding 100 amperes, single or three phase at nominal LV are required to be inspected, tested and certified at least **once every five years** including LV fixed electrical installation located in any of the following type of premises:

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(a) hotels and guest houses,
(b) hospitals, maternity homes, and old people's homes,
(c) schools and institutions, and
(d) childcare centers etc.

12.4.3 Renewal of electrical installation

12.4.3.1 Subject to code 12.4.1, all electrical installations shall be due for renewal after 30 years of use.

12.4.3.2 No electrical installation shall remain in service for more than 35 years.

12.4.3.3 The relevant requirements of Codes 12.1, 12.2 and/or 12.3 shall apply to renewed electrical installations.

12.5 Certification and Reporting

12.5.1 General

12.5.1.1 Subject to code 12.1.1 the required certification of works shall be made on prescribed forms specified by the Chief Inspector, and the completed forms signed and issued as the Electrical Installation Certificate.

12.5.1.2 Any defects or omissions revealed in the works shall be made good and successfully tested before a Certificate is issued.

12.5.2 Electrical Installation Certificate

12.5.2.1 An Electrical Installation Certificate shall be prepared and signed by a competent person or persons in respect of the design, construction, inspection and testing of a new installation or for an alteration/addition to an existing installation where new circuits have been introduced.

12.5.2.2 In the case of a repair, alteration or addition to an installation, only the affected parts of the installation need to be inspected, tested and certified.

12.5.2.3 The Electrical Installation Certificate shall indicate the responsibility(ies) for design, construction, inspection and testing.

12.5.2.4 The schedule of Inspections and the schedule of Test Results shall be prepared and issued as Inspection & Test Report to validate the Electrical Installation Certificate.

12.5.2.5 The Electrical Installation Certificate together with the Inspection & Test Report shall be given to the person ordering the work if the results of the inspection and tests are satisfactory and duplicates shall be retained by the electrical contractor or electrical professional or inspector that certified the works. (Sample of the Electrical Installation Certificate is shown in Appendix 4a.)

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12.5.3 Minor electrical installation works certificate

12.5.3.1 A Minor Electrical Works Installation Certificate shall be prepared and signed by a competent person in respect of inspection and testing of an installation for which an alteration/addition does not extend to the introduction of a new circuit.

12.5.3.2 The Minor Electrical Works Installation Certificate shall indicate the responsibility for design, construction, inspection and testing. (Sample of Minor Electrical Works Installation Certificate is shown in Appendix 4b.)

12.5.4 Periodic inspection report and test certificate

12.5.4.1 A Periodic Inspection Report shall be prepared and signed by a competent person or persons in respect of periodic inspection and testing of an installation.

12.5.4.2 The Periodic Inspection Report shall indicate the extent of the periodic inspection undertaken and test results of an installation or any part thereof.

12.5.4.3 The schedule of Inspection and the schedule of Test Results shall be prepared as the Periodic Inspection Report to validate the issue of a Periodic Test Certificate to the owner of the installation who made the request for periodic inspection. [Sample of the Periodic Inspection report and Certificate is shown in Appendix 4c.]

12.6 Directions to Electrical Professional *or Electrical* Contractor

12.6.1 Signing of certificates

12.6.1.1 An electrical professional shall not sign certificates for tests and inspections unless he/she has carried out or supervised the inspections and tests on site and is satisfied with the results of the inspections and tests.

12.6.1.2 An electrical professional shall not sign certificates for tests and inspections carried out by other electrical professionals unless he/she:

(a) has received the appropriate results of inspections and tests certified by other electrical professionals;
(b) is satisfied with the results of the tests and inspections;
(c) is satisfied that the certificates or inspection reports submitted to him are completed and signed by electrical professional of appropriate grade and in compliance with the Electrical Wiring Regulations; and
(d) has taken reasonable steps to ascertain that the tests and inspections have been genuinely carried out.

12.6.2 Dates of tests, inspections and certification

12.6.2.1 The actual dates of all tests and inspections may be different from the date of certification.

12.6.2.2 Despite clause 12.6.2.1, for the electrical professional to be satisfied that the inspections and tests results are valid, he/she must ensure that the final inspections, insulation resistance tests and functional tests of protective and control devices are carried out as close to the date of certification as possible.

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12.6.2.3 Other inspections and tests listed under Codes 12.1, 12.2 and 12.3 may be carried out at a reasonable time, normally not exceeding one month, before the date of certification provided that due precautions have been taken to ensure that nothing will have affected the results of these inspections and tests during this period.

12.6.3 Items to be inspected and tested

12.6.3.1 List of items to be inspected and tested for initial tests and periodic tests are provided in code 12.7.4.

12.7 Keeping of Records

12.7.1 Records keeping by owner of electrical installation

12.7.1.1 An owner of an electrical installation shall keep the latest test certificates and make them available for inspection by the Chief Inspector or other authorized person when required.

12.7.1.2 For a high voltage fixed installation the owner shall make available for inspection, when requested by the Chief Inspector, a written summary of safety precautions taken for each event of testing and maintenance work carried out on the installation.

12.7.2 Records keeping by electrical professional or electrical contractor

12.7.2.1 An electrical professional or electrical contractor shall keep proper records on all electrical works carried out for the lesser of 5 years or the time since certification as an electrical professional or licensed as an electrical contractor.

12.7.2.2 The electrical professional or electrical contractor shall ensure that each copy of the records prepared is made available to the owner of the electrical installation upon completion of the works.

12.7.3 Types of records

12.7.3.1 For the purpose of code 12.7.2, the following are acceptable as proper records:

(a) a simple single line diagram with standard symbols as stipulated in LS IEC 60617;

(b) test results against the lists of items to be inspected and tested as detailed in the checklists described in code 12.7.4; and

(c) test data recorded in the Schedule of Test Results for Electrical Wiring.

12.7.3.2 For the purpose of clause 12.7.1.2, a record of the permit-to-work together with a maintenance log are acceptable.

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12.7.4 Checklists

12.7.4.1 Records generated that are considered acceptable shall be based on results of the items of inspection conducted and testing performed according to the checklists numbered 1 to 3 in Appendix 5 for the varying requirements as provided in Table 12-2.

Table 12-2: Checklists for Inspection and testing requirements

Type of Inspection/Test	Checklists to be Used
(a) Periodic inspection and testing for a low voltage installation	No.1
(b) Inspection and testing carried out upon completion of any electrical work for a low voltage installation	Nos. 1 & 2
(c) Inspection and testing for Renewable Energy Power System Installations	No.3

12.7.4.2 Where more than one of the checklists are to be used for an installation, the items to be tested shall follow the sequence stated in code 12.2.1 (*as the records indicated against the items of the checklists used do not indicate the test sequence.*)

12.7.4.3 For high voltage installations that are required to be inspected, tested and certified at least once every year, records showing the results of the items of inspection and testing performed according to checklist numbered 4 in Appendix 5 are generally acceptable.

12.7.4.4 Despite clause 12.7.4.3 and where appropriate for high voltage installations, recommendations given in relevant recognized standards and manufacturer's instructions for commissioning and periodic tests shall also be used.

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PART F

DEFINITIONS/INTERPRETATIONS

The following definitions shall apply in this LEWC, in addition to all the definitions used in the ELL and the Electrical Wiring Regulations:

Accessory	Means device other than current-using equipment, associated with such equipment or with the wiring of an installation such as switch, lamp holder, socket, plug-top, ceiling rose, fuse cut-out etc
Ambient temperature	Means the temperature of the air or other medium where the equipment is to be used
Appliance	Means an item of current-using equipment other than a luminaire or an independent motor
Approved loading	Means the maximum current demand approved by a service provider in respect of a fixed electrical installation
Arm's reach	Means a zone of accessibility to touch, extending from any point on a surface where persons usually stand or move about to the limits which a person can reach with a hand in any direction without assistance.
Artisan	Means a person who has trained and successfully completed an apprenticeship program as provided in the Certification and Licensing of Electrical Professionals and Contractors Regulations
Barrier	Means a part providing a defined degree of protection against contact with live parts from any usual direction of access
Basic insulation	Means insulation applied to live parts to provide basic protection against electric shock and which does not necessarily include insulation used exclusively for functional purposes
Bonding conductor	Means a protective conductor providing equipotential bonding
Building void	Means a space within the structure or the components of a building accessible only at certain points. Such voids include the space within partitions, suspended floors, ceilings and certain types of window frame, door frame and architrave
Breaking capacity	Means the value of current at which a switch, a switch-disconnector, a circuit-breaker or a fuse is capable of breaking a circuit at a voltage and under conditions of use and behavior specified by its manufacturer
Bunched	Means where two or more cables are contained within a single conduit, duct, ducting, or trunking or, if not enclosed, are not separated from each other by a specified distance
Burrs	Means a rough edge or ridge left on an object by the action of a tool or machine
Cable	Means a current-carrying conductor

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Cable cleat	Means a component of a support system, which consists of elements spaced at intervals along the length of the cable or conduit and which mechanically retains the cable or conduit
Cable coupler	Means a means of enabling the connection or disconnection, at will, of two flexible cables consisting of a connector and a plug
Cable ducting	Means an enclosure of metal or insulating material, other than conduit or cable trunking, intended for the protection of cables which are drawn in after erection of the ducting
Cable saddle	Means device used to secure a cable to surfaces or walls
Cable trunking	Means a closed enclosure normally of rectangular cross-section, of which one side is removable or hinged, used for the protection of cables and for the accommodation of other electrical equipment
Catenary wire	Means steel support wire, used to span the gap between two buildings, and from which electrical cables are then suspended
Chief Inspector	Means the designated head of the Inspectorate Division of the LERC or authorized representative
Circuit	Means an assembly of electrical equipment supplied from the same origin and protected against overcurrent by the same protective device(s)
Circuit-breaker	Means a device capable of making, carrying and breaking normal load currents and also making and automatically breaking, under pre-determined conditions, abnormal currents such as short-circuit currents. It is usually required to operate infrequently although some types are suitable for frequent operation
Circuit protective conductor (cpc)	Means a protective conductor connecting exposed-conductive parts of equipment to the main earthing terminal
Class I equipment	Means an equipment in which protection against electric shock does not rely on basic insulation only, but which includes means for the connection of exposed-conductive parts to a protective conductor in the fixed wiring of the installation (see BS 2754)
Class II equipment	Means an equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions such as supplementary insulation are provided, there being no provision for the connection of exposed metalwork of the equipment to a protective conductor, and no reliance upon precautions to be taken in the fixed wiring of the installation (see BS 2754).
Class III equipment	Means an equipment in which protection against electric shock relies on supply at SELV and in which voltages higher than those of SELV are not generated (see BS 2754)
Cold tail	Means the part of the heating mat or cable that does not heat up and is used for making the electrical connection to the thermostat or junction box

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Competent person	Means a person who has received the requisite electrical training and adequate practical skills in accordance with the Certification and Licensing of Electrical Professionals and Contractors Regulations and has to undertake electrical works adequately and safely in accordance with the requirements of the LEWC and the Liberia Electrical Wiring Regulations.
Conductor	Means a wire or other form of metal used for conveying electric current from one piece of electrical equipment to another or to earth or any material allowing electrical charges to flow easily
Conduit	Means a part of a closed wiring system for cables in electrical installations, allowing them to be drawn in and/or replaced, but not inserted laterally
Connector	Means the part of a cable coupler or of an appliance coupler which is provided with female contacts and is intended to be attached to the end of the flexible cable remote from the supply
Consumer (control) unit or electricity control unit	A particular type of distribution board comprising a coordinated assembly for the control and distribution of electrical energy, principally in residential premises, incorporating manual means of double-pole isolation on the incoming circuit(s) and an assembly of one or more fuses, circuit-breakers, residual current operated devices or signaling and other devices purposely manufactured for such use.
Current	Means flow of free electrons in a conductor; measured in amperes
Current-carrying capacity of a conductor	Means the maximum current which can be carried by a conductor under specified conditions without its steady state temperature exceeding a specified value
Current-using equipment	Means equipment which converts electrical energy into another form of energy, such as light, heat or motive power
Cut-out	Means a piece of electrical equipment that links the electricity mains or service cable and the internal wires to a premises or installation
Danger	Means risk of injury to persons (and livestock where expected to be present) from: (i) fire, electric shock and burns arising from the use of electrical energy, and (ii) mechanical movement of electrically controlled equipment, in so far as such danger is intended to be prevented by electrical emergency switching or by electrical switching for mechanical maintenance of non-electrical parts of such equipment
Design current (of a circuit)	Means the magnitude of the current (rms value for AC) to be carried by the circuit in normal service.
Direct contact	Means contact of persons or livestock with live parts
Disconnector (also called an Isolator)	Means a mechanical switching device which, in the open position, complies with the requirements specified for isolation.

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Distribution board	Means an assembly containing switching or protective devices (e.g. fuses, circuit-breakers, residual current operated devices) associated with one or more outgoing circuits fed from one or more incoming circuits, together with terminals for the neutral and protective circuit conductors. It may also include signaling and other control devices such as means of isolation
Distribution circuit	Means a (voltage) band II circuit connecting the origin of the installation to: (i) an item of switchgear, or (ii) an item of control gear, or (iii) a distribution board to which one or more final circuits or items of current-using equipment are connected (see also definition of Final circuit). Means a distribution circuit may also connect the origin of an installation to an outlying building or separate installation, when it is sometimes called a sub-main
Double insulation	Means insulation comprising both basic insulation and supplementary insulation
Duct	Means a closed passageway formed underground or in a structure and intended to receive one or more cables which may be drawn in
Ducting	*(see Cable ducting*
Earth	Means a the conductive mass of the Earth, whose electric potential at any point is conventionally taken as zero
Earth electrode	Means a conductor or group of conductors in intimate contact with, and providing an electrical connection to, Earth
Earth electrode resistance	Means the resistance of an earth electrode to Earth
Earth fault current	Means a fault current which flows to Earth
Earth fault loop impedance	Means the impedance of the earth fault current loop starting and ending at the point of earth fault. This impedance is denoted by the symbol Zs. The earth fault loop comprises the following, starting at the point of fault: (i) the circuit protective conductor, and (ii) the consumer's earthing terminal and earthing conductor, and (iii) for: • TN systems, the metallic return path, or • TT and IT systems, the earth return path, and (iv) the path through the earthed neutral point of the transformer, and (v) the transformer winding, and (vi) the phase conductor from the transformer to the point of fault.

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Earth leakage current	Means leakage current that is flowing to earth. *(see also Protective conductor current).*
Earthed concentric wiring	Means a wiring system in which one or more insulated conductors are completely surrounded throughout their length by a conductor, for example a metallic sheath, which acts as a PEN conductor.
Earthed equipotential zone	Means a zone within which exposed-conductive parts and extraneous-conductive parts are maintained at substantially the same potential by bonding, such that, under fault conditions, the differences in potential between simultaneously accessible exposed- and extraneous-conductive parts will not cause electric shock
Earthing	Means connection of the exposed-conductive parts of an installation to the main earthing terminal of that installation
Earthing conductor	Means a protective conductor connecting the main earthing terminal of an installation to an earth electrode or to other means of earthing
Electric shock	Means a dangerous physiological effect resulting from the passing of an electric current through a human body or livestock OR the current forced through the nervous system of the body by external voltage
Electrical contractor	Means a person duly licensed to undertake electrical works or energy efficiency contracting as a firm through electrical professional(s)
Electrical equipment	Means any item for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, wiring systems, accessories, appliances and luminaires
Electrical installation	Means an assembly of associated electrical equipment supplied from a common origin to fulfil a specific purpose and having certain coordinated characteristics
Electrically independent (of earth electrodes**)**	Means earth electrodes located at such a distance from one another that the maximum current likely to flow through one of them does not significantly affect the potential of the other(s).
Electrical professional	Means: (a) an electrician certified by LERC to perform electrical wiring works; or (b) an electrical works inspector; (c) a solar PV installer that is certified by an accredited institution and licensed by LERC to install solar PV systems; or (d) an energy auditor duly licensed by LERC to perform energy audits

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Electrical work	Means all work and services associated with electrical wiring, solar PV installation (including solar plug and play systems), and energy efficiency
Electrical works	Means specific electrical work and services – (i) within an electrical system relating to the installation and maintenance of equipment and facilities for the production and delivery of electricity to end users including, wiring both internal and external OR (ii) in relation to the installation, commissioning, inspection, testing, maintenance, modification or repair of a low voltage or high voltage fixed electrical installation, RE installation, energy efficiency audits, and includes the supervision and certification of that work and the certification of design of that installation
Electrode water heater	Means equipment for the electrical heating of water or electrolyte by the passage of an electric current between electrodes immersed in the water or electrolyte
Emergency switching	Means an operation intended to remove, as quickly as possible, danger, which may have occurred unexpectedly
Enclosure	Means a part providing protection of equipment against certain external influences and in any direction protection against direct contact
Energy auditor	Means an engineer certified by an accredited institution to inspect buildings or industrial processes and assess energy use and make recommendations for optimizing efficiency and minimizing costs
Energy efficiency	Means the process of reducing the amount of energy (electrical or thermal) required to provide products and services with wiring or piping systems
Equipment	*(see Electrical equipment)*
Equipotential bonding	Means electrical connection maintaining various exposed-conductive parts and extraneous-conductive parts at substantially the same potential.
Equipotential zone	*(see Earthed equipotential zone).*
Exposed-conductive part	Means a conductive part of equipment which can be touched and which is not a live part but which may become live under fault conditions
External influence	Means any influence external to an electrical installation which affects the design and safe operation of that installation
Extra-low voltage	*(see Voltage, nominal).*
Extraneous-conductive part	Means a conductive part liable to introduce a potential, generally earth potential, and not forming *(or that does not form)* part of the electrical installation
Fault	Means a circuit condition in which current flows through an abnormal or unintended path. *[This may result from an insulation*

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	failure or a bridging of insulation. Conventionally the impedance between live conductors or between live conductors and exposed- or extraneous-conductive parts at the fault position is considered negligible]
Fault current	Means a current resulting from occurrence of a fault
Final circuit	Means a circuit connected directly to current-using equipment, or to a socket outlet or socket outlets or other outlet points for the connection of such equipment
Fixed electrical installation	*Same meaning as fixed equipment or appliance* – (Examples include distribution boards, wiring installations and lighting fittings, etc., that are fixed in premises.
Fixed equipment or appliance	Means equipment or appliance designed to be fastened to a support or otherwise secured in a specific location
Flame spread	Means the sliding movement of the flaming ignition point over the surface of a solid combustible
Flexible cable	Means a cable whose structure and materials make it suitable to be flexed while in service
Flexible cord	Means a flexible cable in which the cross-sectional area of each conductor does not exceed 4 mm^2
Flexible wiring system	Means a wiring system designed to provide mechanical flexibility in use without degradation of the electrical components
Functional earthing	Means connection to Earth necessary for proper functioning of electrical equipment
Functional extra-low voltage (FELV)	Means an extra-low voltage system in which not all of the protective measures required for SELV or PELV have been applied
Functional switching	Means an operation intended to switch 'on' or 'off' or vary the supply of electrical energy to all or part of an installation for normal operating purposes
Fuse	Means a device which by the melting of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.
Fuse carrier	Means the movable part of a fuse designed to carry a fuse link
Fuse element	Means a part of a fuse designed to melt when the fuse operates
Fuse link	Means a part of a fuse, including the fuse element(s), which requires replacement by a new or renewable fuse link after the fuse has operated and before the fuse is put back into service
Fused switch means	Means a switch which has a fuse to protect whatever appliance the switch is controlling
Hazard	Means anything that can cause harm
High voltage	*(see Voltage, nominal).*

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Highway	Means any way (other than a waterway) over which there is public passage and includes the highway verge and any bridge over which, or tunnel through which, the highway passes
Highway distribution board	Means a fixed structure or underground chamber, located on a highway, used as a distribution point, for connecting more than one highway distribution circuit to a common origin. Street furniture which supplies more than one circuit is defined as a highway distribution board. The connection of a single temporary load to an item of street furniture shall not in itself make that item of street furniture into a highway distribution board.
Highway distribution circuit	Means a (voltage) band II circuit connecting the origin of the installation to a remote highway distribution board or items of street furniture. It may also connect a highway distribution board to street furniture
Indirect contact	Means contact of persons or livestock with exposed-conductive parts which have become live under fault conditions
Installation	*(see Electrical installation)*
Instructed person	Means a person adequately advised or supervised by skilled persons to enable him/her to avoid dangers which electricity may create
Insulation	Means suitable non-conductive material enclosing, surrounding or supporting a conductor
Isolation	Means a function intended to cut off for reasons of safety the supply from all, or a discrete section, of the installation by separating the installation or section from every source of electrical energy
Isolator (also known as disconnector)	Means a mechanical switching device which, in the open position, complies with the requirements specified for isolation. An isolator is otherwise known as a disconnector
Ladder	Means a support consisting of a series of transverse supporting elements rigidly fixed to main longitudinal supporting members
Leakage current	Means electric current in an unwanted conductive path under normal operating conditions
Linked circuit-breaker	Means a circuit-breaker the contacts of which are so arranged as to make or break all poles simultaneously or in a definite sequence
Live part	Means a conductor or conductive part intended to be energized in normal use, including a neutral conductor but, by convention, not a PEN conductor
Live work	Means electrical work on or near any live conductor where a worker is exposed to energized conductors, terminals, busbars or contacts
Low voltage	*(see Voltage, nominal).*

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Luminaire	Means equipment which distributes, filters or transforms the light from one or more lamps, and which includes any parts necessary for supporting, fixing and protecting the lamps, but not the lamps themselves, and, where necessary, circuit auxiliaries together with the means for connecting them to the supply. For the purposes of the Regulations a lamp holder, however supported, is deemed to be a luminaire
Luminaire supporting coupler (LSC)	Means a means, comprising an outlet and plug, providing mechanical support for a luminaire and the electrical connection to and disconnection from a fixed wiring installation.
LV switchgear and control gear assembly	Means a combination of one or more low voltage switching devices together with associated control, measuring, signaling, protective, regulating equipment, etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnection and structural parts. The components of the assembly may be electromechanical or electronic. The assembly may be either type-tested or partially type-tested (see BS EN 60439-1).
Main earthing terminal	Means the terminal or bar provided for the connection of protective conductors, including equipotential bonding conductors, and conductors for functional earthing, if any, to the means of earthing
Mechanical maintenance	Means the replacement, refurbishment or cleaning of lamps and non-electrical parts of equipment, plant and machinery
Neutral conductor	Means a conductor connected to the neutral point of a system and contributing to the transmission of electrical energy. The term also means the equivalent conductor of an IT or DC. system unless otherwise specified in the Regulations and also identifies either the mid-wire of a three-wire DC circuit or the earthed conductor of a two-wire earthed DC circuit
Nominal voltage	*(see Voltage, nominal)*
Obstacle	Means a part preventing unintentional contact with live parts but not preventing deliberate contact
Overcurrent	Means current exceeding the rated value. For conductors the rated value is the current-carrying capacity. (or a greater level of current than the materials in use will tolerate for a long period of time)
Overcurrent detection	Means a method of establishing that the value of current in a circuit exceeds a predetermined value for a specified length of time
Overload	Means an overcurrent occurring in a circuit which is electrically sound
PELV (protective extra-low voltage	Means an extra-low voltage system which is not electrically separated from earth, but which otherwise satisfies all the requirements for SELV

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PEN conductor	Means a conductor combining the functions of both protective conductor and neutral conductor
Person in-charge	Means an electrical professional assigned by an electrical contractor or the owner of fixed electrical installation to take charge of carrying out of electrical work for the installation
Phase conductor	Means a conductor of an AC system for the transmission of electrical energy other than a neutral conductor, a protective conductor or a PEN conductor. The term also means the equivalent conductor of a DC system unless otherwise specified in the Regulations
Phase voltage	Means voltage measured across a single component in a three-phase source or load
Plug	Means a device, provided with contact pins, which is intended to be attached to a flexible cable, and which can be engaged with a socket outlet or with a connector
Point (in wiring)	Means a termination of the fixed wiring intended for the connection of current-using equipment
Power factor	Means the number less than 1.0, used to represent relationship between the apparent and true power of a circuit
Portable equipment or appliance	Means electrical equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply
Prospective fault current	Means the value of overcurrent at a given point in a circuit resulting from a fault of negligible impedance between live conductors having a difference of potential under normal operating conditions, or between a live conductor and an exposed-conductive part.
Protective conductor	Means a conductor used for some measures of protection against electric shock and intended for connecting together any of the following parts: (i) exposed-conductive parts (ii) extraneous-conductive parts (iii) the main earthing terminal (iv) earth electrode(s) (v) the earthed point of the source, or an artificial neutral
Protective conductor current	Means electric current which flows in a protective conductor under normal operating conditions
Protective multiple earthing (PME)	Means an earthing arrangement, found in TN-C-S systems, in which the supply neutral conductor is used to connect the earthing conductor of an installation with Earth
Radial final circuit	Means a type of fixed wiring that feeds one piece of suitable cable from one power point to another until it reaches the last point on the circuit and does not return back to the consumer unit or power source.
Risk	Means the chance of being harmed by a hazard

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Reduced low voltage system	Means a system in which the nominal phase to phase voltage does not exceed 110 volts and the nominal phase to earth voltage does not exceed 63.5 volts
Reinforced insulation	Means single insulation applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard. The term 'single insulation' does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation
Residual current	Means the algebraic sum of the currents in the live conductors of a circuit at a point in the electrical installation.
Residual current device	Means a mechanical switching device or association of devices intended to cause the opening of the contacts when the residual current attains a given value under specified conditions.
Residual operating current	Means residual current which causes the residual current device to operate under specified conditions
Resistance	Means opposition to the flow of electrons (current)
Resistance area (for an earth electrode only)	Means the surface area of ground (around an earth electrode) on which a significant voltage gradient may exist
Responsible person	Means an electrical professional appointed in writing by an electrical contractor or the owner of fixed electrical installation to operate and maintain the installation
Restrictive conductive location	Means a location comprised mainly of metallic or conductive surrounding parts, within which it is likely that a person will come into contact through a substantial portion of their body with the conductive surrounding parts and where the possibility of preventing this contact is limited
Ring final circuit	Means a final circuit arranged in the form of a ring and connected to a single point of supply
SELV (separated extra-low voltage)	Means 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. OR an extra-low voltage electrical circuit that is electrically separated from other circuits that carry higher voltages, isolated from the earth and from the protective earthing conductors of other circuits.
Service	Means electricity supplied to a customer by a service provider through distribution and supply network or for stand-alone system facilities operated under a license or permit issued by LERC
Service box (or panel)	Means the link between the external wires coming from the service provider's network and the internal wires of the homes

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	electrical system or installation *OR the central distribution point that connects the service wire to the exit wires*
Service Provider	Means a legal entity licensed to provide a regulated activity or service
Shock	*(see Electric shock).*
Shock current	Means a current passing through the body of a person or livestock such as to cause electric shock and having characteristics likely to cause dangerous effects
Short-circuit current	Means an overcurrent resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions
Simultaneously accessible parts	Means conductors or conductive parts which can be touched simultaneously by a person or, in locations specifically intended for them, by livestock. Simultaneously accessible parts may be: live parts, exposed-conductive parts, extraneous-conductive parts, protective conductors or earth electrodes
Skilled person	Means a person with technical knowledge or sufficient experience to enable him/her avoid dangers which electricity may create
Socket outlet	Means a device, provided with female contacts, which is intended to be installed with the fixed wiring, and intended to receive a plug.
Space factor	Means the ratio (expressed as a percentage) of the sum of the overall cross-sectional area of cables (including insulation and any sheath) to the internal cross-sectional area of the trunking in which they are installed. (The effective overall cross-sectional area of a non-circular cable is taken as that of a circle of diameter equal to the major axis of the cable.)
Spur	Means a branch from a ring final circuit
Stationary equipment	Means electrical equipment which is either fixed, or equipment having a mass exceeding 18 kg and not provided with a carrying handle
Street furniture	Means fixed equipment, located on a highway, the purpose of which is directly associated with the use of the highway
Street located equipment	Means fixed equipment, located on a highway, the purpose of which is not directly associated with the use of the highway
Substation	Means premises or an enclosed part of premises that contains electrical equipment for transforming or converting energy to or from high voltage (other than transforming or converting energy solely for the operation of switching devices or instruments) or for switching, controlling or regulating energy at high voltage and that are large enough to admit the entrance of a person after the electrical equipment is in position;

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Supplementary insulation	Means independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation
Switch	Means a mechanical device capable of making, carrying and breaking current under normal circuit conditions, which may include specified operating overload conditions, and also of carrying for a specified time currents under specified abnormal circuit conditions such as those of short-circuit. It may also be capable of making, but not breaking, short-circuit currents
Switch fuse	Means a fuse that goes into a fused switch
Switch, linked	Means a switch the contacts of which are so arranged as to make or break all poles simultaneously or in a definite sequence
Switchboard	Means an assembly of switchgear with or without instruments, but the term does not apply to groups of local switches in final circuits
Switchgear	Means an assembly of main and auxiliary switching apparatus for operation, regulation, protection or other control of an electrical installation
Switching	Means making or breaking a current under normal circuit conditions
Switch room	Means premises or an enclosed part of premises that contains electrical equipment for switching, controlling or regulating electricity at low voltage and above and that are large enough to admit the entrance of a person after the electrical equipment is in position
System	Means an electrical system consisting of a single source of electrical energy and an installation. For certain purposes of the LEWC, types of system are identified as follows, depending upon the relationship of the source, and of exposed-conductive parts of the installation, to Earth – - **TN system:** a system having one or more points of the source of energy directly earthed, the exposed-conductive parts of the installation being connected to that point by protective conductors - **TN-C system:** a system in which neutral and protective functions are combined in a single conductor throughout the system - **TN-S system:** a system having separate neutral and protective conductors throughout the system - **TN-C-S system:** a system in which neutral and protective functions are combined in a single conductor in part of the system - **TT system:** a system having one point of the source of energy directly earthed, the exposed-conductive parts of the installation being connected to earth electrodes electrically

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	independent of the earth electrodes of the source parts of the electrical installation being earthed
Temporary supply unit	Means an enclosure containing equipment for the purpose of taking a temporary electrical supply safely from an item of street furniture.
Trunking	*(see Cable trunking).*
Voltage	Means difference in electrical charge between two points in a circuit, expressed in volts; force available to push current round a circuit
Voltage, nominal	Means voltage by which an installation (or part of an installation) is designated. The following ranges of nominal voltage (rms values for AC) are defined: - **Extra-low** - Normally not exceeding 50 V AC or 120 V ripple-free DC, whether between conductors or to Earth, - **Low -**Normally exceeding extra-low voltage but not exceeding 1000 V AC or 1500 V DC between conductors, or 600 V AC or 900 V DC between conductors and Earth - High - Exceeding 1kV AC or 1.5kV ripple-free DC and in accordance with the LS IEC 61936-1; The actual voltage of the installation may differ from the nominal value by a quantity within normal tolerances
Voltage Band I	Means levels of voltage which are too low to provide serious electric shocks; effectively this limits the band to extra-low voltage (ELV), including telecommunications, signalling, bell, control and alarm circuits.
Voltage Band II	Means all voltages used in electrical installations not included in Band I. This means that all 230/400 V (240/415 V) supplies are included in Band II.
Wiring system	Means an assembly made up of cable or busbars and parts which secure and, if necessary, enclose the cable or busbars.

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SCHEDULES

SCHEDULE 1— CLEARANCES (OVERHEAD/HORIZONTAL)

(Ref code -9.12.4)

Schedule 1a: Overhead Line Clearances

Type of installation for LV or HV	**Vertical Clearance from Ground for various crossings (in meters)**					
	Main road	Public Street	Private Driveway	Pedestrian Walkway	Railway crossing	Waterways
0.4kV Bare conductor	7.5	5.5	5.0	4.5	7.0	20 (from highest water level)
0.4kV AB conductor	7.5	5.5	5.0	4.0	7.0	
11kV Bare conductor	8.0	6.0	6.0	6.0	7.5	
22/33kVBare conductor	8.0	6.0	6.0	6.0	7.5	

Schedule 1b: Horizontal Clearance from Buildings, Roads & Telecom lines(Ref code -9.12.4)

Type of installation for LV or HV	**Clearance from Building structure (m)**		**Clearance from Telecom Line (m)**	
	Horizontal clearance	Height Above structure	Parallel lines	Lines crossing
0.4kV Bare conductor	≤2	≥3	2	1.5
0.4kV AB conductor	≤0.5	≥2	0.3	0.3
11kV Bare conductor	>3.0	-	2.0	1.5
22/33kVBare conductor	>3.0	-	2.3	1.8
132 or 225kV line	>15	-	2.8 [But generally Not Recommended for long distances]	
Line supports & stays	Shall be located at a distance of at least 2 meters from edge of road			

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Schedule 2: Procedure for Measurement of Earth Electrode

RESISTANCE (E.E.R)- [ref codes 12.1.3 & 12.2.6]

The following procedure shall be followed:

1. Set the pointer at zero.
2. Auxiliary electrodes “B” and “C” must be driven to a reasonably good depth into the ground.
3. Ensure that the resistance areas of the earth electrodes must not overlap.
4. Ensure that the two auxiliary electrodes are in a straight line with the main electrode “A” under test.
5. Ensure that the test leads do not cross each other.
6. Recommended results must be less than 8 ohms

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APPENDICES

Appendix 1: Samples – Permit-to-Work and Sanction-for-Test

Appendix 1a: Permit-To-Work (Sample)

.....DIVISION/OFFICE Permit No..... **.....DEPARTMENT Location.....**	
PART 1 – ISSUE **(To be completed by Responsible Person)**	
I hereby declare that it is safe to test on the following high voltage electrical equipment which has been made dead, isolated, discharged and earthed (if necessary) in accordance with the safety precautions in Code 4 of the LEWC and and the Electricity (Wiring) Regulations. I have drawn the attention of the Person in-charge of the work to these precautions. I have physically identified the high voltage electrical equipment, explained the extent of the test and demonstrated the safety arrangements to the Person in-charge. ☐ Please tick in the appropriate boxes	
1. ELECTRICAL EQUIPMENT TO BE WORKED ON	☐High Voltage Fixed Electrical Installation ☐ Low Voltage Fixed Electrical Installation
(A) Distribution Board and the Parts at Its Downstream	☐ Distribution Board ☐ Final Circuit ☐ Socket Outlet ☐ Double Pole Switch ☐ Single Pole Switch ☐ Fused Connection Unit ☐ Luminaire ☐ Water Heater ☐ Air-Conditioner ☐ Exhaust Fan ☐Others (Please specify).....
(B) Upstream of Distribution Board	☐ Main Switchboard ☐ Rising Main ☐ Distribution Sub-Circuit ☐ Sub-Switchboard ☐ Busbar Chamber ☐ MCCB ☐Fused Switch ☐Others (Please specify).....
2. LOCATION OF ELECTRICAL EQUIPMENT	☐ Switch Room ☐ Meter Room ☐ Cable Duct Room ☐ Room No. ☐Others (Please specify) .....
3. DETAILS OF WORK TO BE DONE	**Category:** ☐ Addition ☐ Modification ☐ Replacement ☐ Repair ☐ Maintenance ☐ PITC ☐Others (Please specify) .....

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	Details: ……. **……..**
4. EXACT POINT WHERE ELECTRICAL EQUIPMENT IS ISOLATED	☐4-pole ACB ☐4-pole MCCB ☐Double-pole MCB ☐Others (Please specify) .....
5. EXACT POINTS WHERE ELECTRICAL EQUIPMENT IS EARTHED:	
6. SAFETY LOCKS APPLIED AT:	
7. CAUTION NOTICES AND DANGER NOTICES HAVE BEEN POSTED AT:	
8. SPECIAL INSTRUCTIONS, OR SAFETY MEASURES:	

Name (Responsible Person): .....
Signed by (Responsible Person) ……. .....
Contact Tel. No: .....
Date: ..... Time: .....

PART 2 — RECEIPT (To be completed by Person in-charge)

1. I acknowledge receipt of this permit-to-work and the key for the safety locks. I have read the content of this permit-to-work and I certified that where applicable the electrical equipment is switched off and isolated on these premises. Safety devices and earths (if applicable) will not be removed until this permit-to-work has been cancelled and permission has been obtained from the Responsible Person
2. I declare that I accept the responsibility for carrying out work on the electrical equipment described on this permit-to-work and that no attempt will be made by me or by the persons under my control to carry out work on other electrical equipment.
3. I will retain this permit-to-work while the work described in Part 1 is in progress and will return it to the Responsible Person when the work is completed or stopped.

Name: (Person in-charge) .....

Signed (Person in-charge): .....

Contact Tel. No: ..... Date: ..... Time: .....

In the employment of (or Engaged by) .....

NOTE: THIS PERMIT IS NOT VALID UNTIL PARTS 1 & 2 HAVE BEEN SIGNED

PART 3 — CLEARANCE
(To be completed by Person in-charge)

I hereby declare that work described in Part 1 of this permit-to-work has been satisfactorily completed/stopped*, and all persons under my charge have been withdrawn and warned that the above electrical equipment is no longer safe to work on. All tools and temporary connections have been removed.
Signed (Person in-charge): .....Date: …….. Time .....

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* *Delete as appropriate*
PART 4 — CANCELLATION **(To be completed by Responsible Person)**
I hereby declare that the work described in Part 1 of this permit-to-work has been satisfactorily completed/stopped* and that this permit-to-work is cancelled. The original permit-to-work has been returned to me and will be passed to the relevant electrical contractor or owner of the fixed electrical installation for their keeping for at least five (5) years. Signed by (Responsible Person) ……..... Date..... Time ..... * *Delete as appropriate.*

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Appendix 1b: Sanction-for-Test – High Voltage (Sample)

.....DIVISION/OFFICE Permit No..... **.....DEPARTMENT Location.....**	
PART 1 – ISSUE **(To be completed by Responsible Person)**	
I hereby declare that it is safe to test on the following high voltage electrical equipment which has been made dead, isolated, discharged and earthed (if necessary) in accordance with the safety precautions in Code 4 of the LEWC and the Electricity (Wiring) Regulations. I have drawn the attention of the Person in-charge of the work to these precautions. I have physically identified the high voltage electrical equipment, explained the extent of the test and demonstrated the safety arrangements to the Person in-charge.	
1. HIGH VOLTAGE ELECTRICAL EQUIPMENT TO BE TESTED ON	
2. LOCATION OF HIGH VOLTAGE ELECTRICAL EQUIPMENT	
3. DETAILS OF TEST TO BE DONE	
4. EXACT POINT OF ISOLATION	HV Isolation Point:
	LV Isolation Point:
5. SAFETY LOCKS APPLIED AT :	
6. CAUTION NOTICES AND DANGER NOTICES POSTED AT :	
7. EXACT POINTS WHERE HIGH VOLTAGE ELECTRICAL EQUIPMENT IS EARTHED	
8. SPECIAL INSTRUCTIONS, OR SAFETY MEASURES:	
Name (Responsible Person): ..... Signed by (Responsible Person) …… ..... Contact Tel. No: ..... Date: ..... Time:	

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PART 2 — RECEIPT (To be completed by Person in-charge)

1. I acknowledge receipt of this sanction-for-test and the key for the safety locks. I have read the content of this sanction-for-test and I certified that where applicable the high voltage electrical equipment is switched off and isolated on these premises.

2. I declare that I accept the responsibility for carrying out testing of the high voltage electrical equipment described on this sanction-for-test and that no attempt will be made by me or by the persons under my control to test on other electrical equipment.

3. I will retain this sanction-for-test while the test described in Part 1 is in progress and will return it to the Responsible Person when the test is completed or stopped.

Name: (Person in-charge) .....

Signed (Person in-charge): .....

Contact Tel. No: ..... Date: ..... Time: .....

In the employment of (or Engaged by) .....

NOTE: THIS PERMIT IS NOT VALID UNTIL PARTS 1 & 2 HAVE BEEN SIGNED

PART 3 — CLEARANCE
(To be completed by Person in-charge)

I hereby declare that test described in Part 1 of this sanction-for-test has been satisfactorily completed/stopped*, and all persons under my charge have been withdrawn and warned that the above high voltage electrical equipment is no longer safe to test on. All tools and temporary connections have been removed. The current earthing arrangement is the same as that specified in Part I of this sanction-for-test / has been changed as shown in enclosed drawings *.

Signed (Person in-charge): .....Date: …….. Time .....
** Delete as appropriate*

PART 4 — CANCELLATION
(To be completed by Responsible Person)

I hereby declare that the test described in Part 1 of this sanction-for-test has been satisfactorily completed / stopped* and that this sanction-for-test is cancelled. The original sanction-for-test has been returned to me and will be passed to the relevant electrical contractor or owner of the fixed electrical installation for their keeping for at least five years.

Signed by (Responsible Person) …….....

Date..... Time .....

** Delete as appropriate.*

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APPENDIX 2: LOGBOOK SAMPLES

Appendix 2a: HV Padlock Movement Logbook (Sample)

HV PADLOCK MOVEMENT LOGBOOK (Sample) **LOCATION _____**

Date	Name	Electrical Professional No.	PTW No.	Position of Locking	Sign	Time for Unlocking	Sign

Appendix 2b: HV Enclosure Access Logbook (Sample)

HV ENCLOSURE ACCESS LOGBOOK (Sample) **LOCATION _____**

Date	Name	Electrical Professional No.	PTW No.	Activity	Time in	Sign	Time Out	Sign

Note: This set of logbooks must be kept inside the equipment safety key box at all times

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APPENDIX 3: REFERENCE STANDARDS FOR THE LEWC

References may be made to the following publications for better applying and understanding of the requirements of the LEWC.

IEC 60079	Electrical apparatus for Explosive atmosphere
IEC 60085	Electrical insulation - Thermal evaluation and designation
IEC 60104	Aluminum-magnesium-silicon alloy wire for overhead line conductors
IEC 60228	Conductors of Insulated Cables
IEC 60238	Edison screw lamp holders
IEC 60309	Plugs, socket outlets and couplers for industrial purposes. Switched socket outlets and connectors with or without interlock
IEC 60332-1-2	Tests on electric and optical fibre cables under fire conditions - Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW premixed flame
IEC 60335-2-41	Household and similar electrical appliances – Particular requirements for pumps
IEC 60335-2-53	Household and similar electrical appliances - Particular requirements for sauna heating appliances and infrared cabins
IEC 60335-2-96	Household and similar electrical appliances - Particular requirements for flexible sheet heating elements for room heating
IEC 60364	Low-voltage electrical installations / Electrical installations of buildings
IEC 60423	Conduit systems for cable management - Outside diameters of conduits for electrical installations and threads for conduits and fittings
IEC 60502-1	Cables for Rated Voltages of 1kV (Um=1.2kV) and 3KV (Um=3.6kV)
IEC 60529	Degree of protection provided by enclosures (IP Code)
IEC 60598	General requirements and tests
IEC 60598-2-18	Luminaires - Particular requirements - Luminaires for swimming pools and similar applications
IEC 60617	Graphical symbols for diagrams
IEC 60669	Switches for household and similar fixed electrical installations
IEC 60800	Heating cables with a rated voltage of 300/500V for comfort heating and prevention of ice formation
IEC 60898	Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations
IEC 60947	Low-voltage switchgear and control gear
IEC 60947-2	Low-voltage switchgear and control gear - Circuit-breakers
IEC 60947-4-1	Low-voltage switchgear and control gear - Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC 60947-7	Low-voltage switchgear and control gear – Ancillary equipment

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IEC 60950	Information technology equipment - Safety
IEC 61008	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)
IEC 61008-1	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) - General rules
IEC 61009	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
IEC 61009-1	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) - General rules
IEC 61034-2	Measurement of smoke density of cables burning under defined conditions - Test procedure and requirements
IEC 61084	Cable trunking and ducting systems for electrical installations
IEC 61089	Round wire concentric lay overhead electrical stranded conductors
IEC 61140	Protection against electric shock - Common aspects for installation and equipment
IEC 61386	Conduit systems for cable management
IEC 61439	Low-voltage switchgear and control gear assemblies
IEC 61534	Power track systems
IEC 61558	Safety of power transformers, power supplies, reactors and similar products
IEC 61558-2-5	Safety of power transformers, power supply units and similar - Particular requirements for shaver transformers and shaver supply units
IEC 61730	Photovoltaic (PV) module safety qualification
IEC 62109	Safety or power converters for use in photovoltaic power system
IEC 62305	Protection against lightning
IEC 62395-1	Electrical resistance trace heating systems for industrial and commercial applications - General and testing requirements
IEC 62606	General requirements for arc fault detection devices
BS EN 62423	Type F and type B residual current operated circuit breakers with and without integral overcurrent protection for household and similar uses
BS EN 50085	Cable trunking systems and cable ducting systems for electrical installations
BS EN 50174	Information technology - Cabling installation
BS EN 50310	Application of equipotential bonding and earthing in buildings with information technology equipment
BS EN 50525-2-12	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Cables with thermoplastic PVC insulation for extensible leads

BS EN 50525-2-21	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Flexible cables with crosslinked elastomeric insulation
BS EN 50525-2-31	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Single core non-sheathed cables with thermoplastic PVC insulation
BS EN 50525-2-41	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Single core cables with crosslinked silicone rubber insulation
BS EN 50525-2-42	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Single core non-sheathed cables with crosslinked EVA insulation
BS EN 50525-2-51	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Oil resistant control cables with thermoplastic PVC insulation
BS EN 50525-2-71	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Flat tinsel cables (cords) with thermoplastic PVC insulation
BS EN 50525-2-83	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Multicore cables with crosslinked silicone rubber insulation
BS EN 50525-3-21	Electric Cables. Low Voltage energy cables of rated voltages up to and including 450/750V. Cables for general applications. Cables with special fire performance. Flexible cables with halogen-free crosslinked insulation, and low emission of smoke
BS EN 50525-3-41	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750V. Cables with special fire performance. Single core non-sheathed cables with halogen-free crosslinked insulation, and low emission of smoke
BS EN 50618	Electric cables for photovoltaic systems
BS EN 60332-1-2	Tests on electric and optical fibre cables under fire conditions - Test for vertical flame propagation for a single insulated wire or cable - Procedure for 1 kW premixed flame
BS EN 60335	Household and similar electrical appliances - Safety
BS EN 60335-2-96	Household and similar electrical appliances. Safety. Particular requirements for flexible sheet heating elements for room heating
BS EN 60423	Conduit systems for cable management - Outside diameters of conduits for electrical installations and threads for conduits and fittings
BS EN 60439	Low-voltage switchgear and control gear assemblies
BS EN 60598	Luminaires
BS EN 60947-1	Low-voltage switchgear and control gear - General rules

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BS EN 60947-2	Low-voltage switchgear and control gear - Circuit breakers
BS EN 60947-3	Low-voltage switchgear and control gear - Switches, disconnectors, switch-disconnectors and fuse combination units
BS EN 60947-4	Low-voltage switchgear and control gear - Contactors and motor-starters - Electromechanical contactors and motor-starters
BS EN 61008	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)
BS EN 61009	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
BS EN 61034-2	Measurement of smoke density of cables burning under defined conditions - Test procedure and requirements
BS EN 61140	Protection against electric shock. Common aspects for installation and equipment
BS EN 61215	Terrestrial photovoltaic (PV) module
BS EN 61386	Conduit systems for cable management
BS EN 61439	Low-voltage switchgear and control gear assemblies
BS EN 61534	Power track systems
BS EN 62305	Protection against lightning
BS EN 62395-1	Electrical resistance trace heating systems for industrial and commercial applications. General and testing requirements
BS 31	Specification - Steel conduit and fittings for electrical wiring
BS 88-2	Low-voltage fuses. Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application). Examples of standardized systems of fuses A to K
BS 88-3	Low-voltage fuses. Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household or similar applications). Examples of standardized systems of fuses A to F
BS 476 Part 20	Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)
BS 546	Specification-Two-pole and earthing-pin plugs, socket outlets and socket outlet adaptors
BS 1363 13	A plugs, socket outlets, adaptors and connection units
BS 3036	Specification - Semi-enclosed electric fuses (ratings up to 100 amperes and 240 volts to earth)
BS 4444	Guide to electrical earth monitoring and protective conductor proving
BS 4607	Non-metallic conduits and fittings for electrical installations
BS 4662	Boxes for flush mounting of electrical accessories. Requirements and test methods and dimensions
BS 4678	Cable trunking
BS 5266	Emergency lighting
BS 5467	Electric cables. Thermosetting insulated, armored cables for voltages of 600/1000V and 1900/3300V
BS 5839	Fire detection and fire alarm systems for buildings

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BS 6004	Electric cables. PVC insulated, non-armored cables for voltages up to and including 450/750V, for electric power, lighting and internal wiring
BS 6387	Specification for performance requirements for cables required to maintain circuit integrity under fire conditions
BS 6701	Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance
BS 6724	Electric cables. Thermosetting insulated, armored cables for voltages of 600/1000V and 1900/3300V, having low emission of smoke and corrosive gases when affected by fire
BS 7211	Electric cables. Thermosetting insulated, non-armored cables for voltages up to and including 450/750V, for electric power, lighting and internal wiring, and having low emission of smoke and corrosive gases when affected by fire
BS 7629	Specification for 300/500V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire
BS 7671	Requirements for electrical installations. IET Wiring Regulations
BS 7846	Electric cables. Thermosetting insulated, armored, fire-resistant cables of rated voltage 600/1000V, having low emission of smoke and corrosive gases when affected by fire. Specification
BS 7919	Electric cables. Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments
BS 8436	Electric cables. Specification for 300/500V screened electric cables having low emission of smoke and corrosive gases when affected by fire, for use in walls, partitions and building voids. Multicore cables
BS 8488	Prefabricated wiring systems intended for permanent connection in fixed installations
BS 8573	Electric cables. Thermosetting insulated, non-armoured cables with a voltage of 600/1000V, for fixed installations, having low emissions of smoke and corrosive gases when affected by fire
AS/NZS 1768	Lightning protection
ANSI UL 1703	Standard for Flat-Plate Photovoltaic modules and panels
UL 1741	Standard for inverters, converters, controllers and interconnection system for use with distributed energy resources
NFPA 780	Standard for the installation of lightning protection systems
References to publications relating to the common personal protective equipment (PPE) and tools used for electrical work	
BS EN IEC 60900	Live working - Hand tools for use up to 1000V AC and 1500V DC
BS EN 60903	Live working - Gloves of insulating material
BS EN ISO 20345	Personal protective equipment - Safety footwear

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BS EN 61111	Matting of insulating material for electrical purposes
BS EN 61112	Blankets of insulating material for electrical purposes
ASTM F1506	Standard performance specification for flame resistant textile materials for wearing apparel for use by electrical professionals exposed to momentary electric arc and related thermal hazards
ICEA S-76-474	Neutral-Supported Power Cable Assemblies with Weather Resistant Extruded Insulation Rated 600 Volts.

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APPENDIX 4: INSPECTION TESTING REPORTS & CERTIFICATION

Appendix 4a: Electrical Installation Certificate

(Ref code 12.5.2)
(Requirements for Liberia Electrical Wiring Regulations)

A. PARTICULARS OF SIGNATORIES TO THE ELECTRICAL INSTALLATION CERTIFICATE

Designer No.1

Name: ..... Company: .....

Location: .....

Postal address: ..... Tel No: .....

Designer No. 2 (if applicable)

Name: ..... Company: .....

Location: .....

Postal address: ..... Tel No: .....

Constructor/Installer

Name: ..... Company: .....

Location: .....

Postal address: ..... Tel. No: .....

Inspector

Name: ..... Company: .....

Location: .....

Postal address: ..... Tel No: .....

B. SUPPLY CHARACTERISTICS AND EARTHING ARRANGEMENTS *Tick boxes and enter details as appropriate*

Earthing Arrangements	**Number and type of Live Conductor**		**Nature of Supply Parameter**	**Supply Protective Device Characteristics**
TN-C ☐	AC ☐	DC ☐	Nominal voltage, U/U_o (1) V	
TN-S ☐	1 -phase, 2 wire ☐	2 -pole ☐	Nominal frequency, f (1) ..... Hz	Type: .....
TN-C-S ☐	2 -phase, 3 wire ☐	3 -pole ☐	Prospective fault current, I_{pf} (2) .....kA	
TT ☐	3 -phase, 3 wire ☐	Other ☐	External loop impedance, Z_o (2) ..... Ω	Nominal current rating ..... A
Alternative source of supply (detailed on attached schedules) ☐	3 -phase, 4 wire ☐		*(Notes: (1) by enquiry, (2) by enquiry or by measurement)*	

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C. PARTICULARS OF INSTALLATION REFERRED TO IN THE CERTIFICATE *Tick boxes and enter details as appropriate*

1.Means of Earthing

Service Provider's facility ☐

Installation Earth Electrode ☐

2. Maximum Demand

Maximum demand (load) ..... Amps

3. Details of Installation Earth Electrode (where applicable)

Type [e.g. rod(s), tape etc.]	Location	Electrode resistance to earth
.....	.....	..... Ω

4. Main Protective Conductors

Earthing conductor: Material ..... CSA ..... Connection verified ☐ Y/N ☐

Main equipotential bonding conductors: Material ..... CSA ..... Connection verified ☐ Y/N ☐

To incoming water and/or gas service ☐ To other elements: .....

5. Main Switch or Circuit-breaker

GS, Type and No. of poles ..... Current rating ..... A Voltage rating V

Location ..... Fuse rating or setting ..... A

Rated residual operating current $I_{\Delta n}$ = ... mA, and operating time of .....ms (at $I_{\Delta n}$) - *Required only where an RCD is suitable and used as a main circuit breaker)*

6. COMMENTS ON EXISTING INSTALLATION (in the case of an alteration or addition:

.....

.....

.....

7. SCHEDULES

The attached Inspection and Test Result Schedules are part of this document, and this Certificate is only valid when Test Result Schedules are attached to it. *(Enter quantities of schedules attached)*

..... Inspection Schedules and .....Test Result Schedules are attached.

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Appendix 4b: Minor Electrical Installation Works Certificate (Sample)

(Ref code 12.5.3)
(Requirements for Liberia Electrical Wiring Regulations)
To be used only for minor electrical work which does not include the provision of a new circuit

PART 1: Description of minor works

1. Description of the minor works
2. Location/Address
3. Date of minor works completed

PART 2: Installation details

1. System of earthing arrangement (where known) TN-C-S ☐ TN-S ☐ TT ☐
2. Method of protection against indirect contact …….
3. Protective device for the modified circuit Type ..... Rating ..... A

Comments on existing installation, including adequacy of earthing and bonding arrangements:

PART 3: Essential Tests

Earth continuity satisfactory ☐ Y/N ☐

Insulation resistance:

Phase/neutral ..... M Ω
Phase/earth ..... M Ω
Neutral/earth ..... M Ω

Earth fault loop impedance ..... Ω

Polarity satisfactory ☐

RCD operation (if applicable). Rated residual operating current $I_{\Delta n}$ ..... mA and operating time of .....ms (at $I_{\Delta n}$)

PART 4 : Declaration

I/We CERTIFY that the said works do not impair the safety of the existing installation, that the said works have been designed, constructed, inspected and tested in accordance with the Liberia Electrical Wiring Regulations and that the said works, to be the best of my/our knowledge and belief, at the time of my/our inspection complied with the Liberia Electrical Wiring Regulations except as detailed in Part 2.

Name:	Signature: .....
For and on behalf of:	Position: .....
Address:	
.....	Date: .....
.....	

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Appendix 4c: Periodic Inspection Report for an Electrical Installation

(Sample - Ref code 12.5.4)
(Requirements for Liberia Electrical Wiring Regulations)

DETAILS OF THE CLIENT

Client: .....

Address: .....

Purpose for which this Report is required:
.....

DETAILS OF THE INSTALLATION Tick boxes as appropriate

Occupier: .....

Installation: .....

Address: .....

Description of Premises: Residential ☐ Commercia☐ Industria☐ Other☐

Estimated age of the Electrical Installation: .....years

Evidence of Alterations or additions: Yes ☐ No ☐ Not apparent ☐

If "Yes", estimate age: ..... years

Date of last inspection: ..... Records available Yes ☐ No ☐

EXTENT AND LIMITATION OF THE INSPECTION

Extent of electrical installation covered by this report: .....

.....

.....

Limitations: .....

.....

This inspection has been carried out in accordance with the Liberia Electrical Wiring Regulations. Cables concealed within trunking and conduits, or cables and conduits concealed under floors, in roof spaces and generally within the fabric of the building or underground have not been inspected.

NEXT INSPECTION

I/We recommend that this installation is further inspected and tested after an interval of not more than ..... months/years, provided that any observations 'requiring urgent attention' are attended to without delay.

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DECLARATION:

INSPECTED AND TESTED BY

Name: ..... Signature: .....

For and on behalf of: ..... Position: .....

Address: .....

..... Date: .....

.....

SUPPLY CHARACTERISTICS AND EARTHING ARRANGEMENTS Tick boxes and enter details, as appropriate

Earthing Arrangements	**Number and type of Live Conductors**	**Nature of Supply Parameter**	**Supply Protective Device Characteristics**
TN-C ☐	AC ☐ DC. ☐	Nominal voltage, U/U_o (1) V	**Type:** .....
TN-S ☐	1 -phase, 2 wire ☐ 2 -pole ☐	Nominal frequency, f (1) ..... Hz	
TN-C-S ☐	2 -phase, 3 wire ☐ 3 -pole ☐	Prospective fault current, I_{pf} (2) .....kA	
TT ☐	3 -phase, 3 wire ☐ Other ☐	External loop impedance, Z_o (2) ..... Ω	Nominal current rating ..... A
Alternative source of supply (to be detailed on attached schedules) ☐	3 -phase, 4 wire ☐	*Notes:* *(1) by enquiry,* *(2) by enquiry or by measurement)*	

PARTICULARS OF INSTALLATION REFERRED TO IN THE REPORT Tick boxes and enter details, as appropriate

Means of Earthing:	**Details of Installation Earth Electrode** (where applicable)		
Service Provider's facility ☐	Type (e.g. rod(s), tape, etc)	Location	Electrode resistance to earth
Installation earth Electrode ☐	.....	.....	..... Ω

Main Protective Conductors

Earthing conductor: Material ..... CSA .....

Main equipotential bonding conductors: Material ..... CSA …….....

To incoming water service ☐ To incoming gas service ☐ To incoming oil service ☐ To structural steel ☐

To lightning protection ☐ To other incoming service(s) ☐ (state details .....)

Main Switch or Circuit-breaker Main Switch or Circuit-breaker

GS, Type and No. of poles ..... Current rating ..... A Voltage rating V

Location ..... Fuse rating or setting ..... A

Rated residual operating current $I_{\Delta n}$ = ... mA, and operating time of .....ms (at $I_{\Delta n}$) - *Required only where an RCD is suitable and used as a main circuit breaker)*

OBSERVATIONS AND RECOMMENDATIONS Tick boxes as appropriate

Recommendations as detailed below

Referring to the attached Schedule(s) of Inspection and Test Results, and subject to the limitations specified at the **Extent and Limitations of the Inspection:**

☐ No remedial work is required ☐ The following observations are made

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.....

.....

.....

.....

.....

.....

One of the following numbers, as appropriate, is to be allocated to each of the observations made above to indicate to the person(s) responsible for the installation the action recommended.

☐ 1. Requires urgent attention ☐ 2. Requires improvement ☐ 3. Requires further investigation

☐ 4. Does not comply with the Liberia Electrical Wiring Regulations. [NB: This does not imply that the electrical installation inspected is unsafe.]

SUMMARY OF THE INSPECTION

Date(s) of the inspection:

.....

General condition of the installation:

.....

.....

.....

Overall assessment: ☐ **Satisfactory** **Unsatisfactory** ☐

SCHEDULE(S)

The attached Inspection and Test Result Schedules are part of this document and this Report is only valid when Test Result Schedules are attached to it. (Enter quantities of schedules attached)

.....Inspection Schedules and ..... Test Result Schedules are attached

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APPENDIX 5: CHECKLISTS FOR INSPECTION & TESTING

(Note: For the use of the following five checklists, please refer to code 12.7.4)

Checklist No. 1—Items for Testing of New or Periodic Testing of Existing LV Installation

Installation Address:

Item No.	Description of Inspection/Test	Reference code((s)/clauses for compliance	Test conducted by:	Date of Test
A. Switchboards, Circuit Breakers and Main Switches				
1	No visible damage to impair safety.	code 12.1.2		
2	Safe access provided.	code 3.1.2 & clause 3.1.3.2		
3	Every circuit breaker and main switch provided with a legible and durable identification label.	codes 2.2.2, 3.1.6, 4.3.2 & 7.1.4		
4	An up-to-date schematic diagram displayed to show the main distribution system.	codes 3.1.6 & 4.2.1 (clause 4.2.1.4)		
5	Link of adequate size installed in neutral circuit.	clause 4.1.3.1.		
6	All accessible live parts screened with insulating plate or earthed metal.	clauses 3.4.2.2 & 4.1.4.11		
7	The overload and fault current protection characteristics of all circuit breakers verified with secondary injection test instruments where appropriate.	clause 12.2.8.3		
8	Lowest insulation resistance being Mohms (not less than 2 Mohm) measured between phases/neutral/ earth.	code 12.2.1 (Table 12-1)		
9	All exposed conductive parts effectively earthed with a maximum earth fault loop impedance being ___ ohms.	Code 7.2.		
10	An up-to-date notice of periodic inspection and testing provided at point of supply (i.e., a switchboard, a circuit	Code 11.6.1 (Where Applicable)		

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	breaker or a distribution board) of the installation.			
B. Substations				
1	A warning notice 'DANGER – SUBSTATION, UNAUTHORISED ENTRY PROHIBITED' provided at every entrance of substation.	code 11.2.4		
2	Suitable locking facilities provided for HV substations.	code 12.3.1		
3	Suitable lighting provided.	codes 3.2.1 & 3.1.8		
4	Suitable ventilation provided.	codes 3.2.1 & 3.1.8		
5	Entrance/exit free of obstruction.	code 3.1.8		
C. Switch Rooms				
1	A warning notice 'DANGER ⎓ ELECTRICITY, UNAUTHORISED ENTRY PROHIBITED' provided at every entrance of switch rooms.	code 11.2.2		
2	Suitable locking facilities provided for HV Switch rooms.	code 12.3.1		
3	Suitable lighting provided.	codes 3.2.1 & 3.1.8		
4	Suitable ventilation provided.	codes 3.2.1 & 3.1.8		
5	Entrance/exit free of obstruction.	code 3.1.8		
D. Busbar Trunking System including Rising Mains				
1	No visible damage to impair safety.	code 12.1.2		
2	Phase identification marked on both ends of main cable/ conductor, and at terminations.	Code 8.3		
3	All joints of metal conduit or trunking to be mechanically sound, electrically continuous and protected against corrosion.	code 8.9.2		
4	All accessible live parts screened with an insulating plate or earthed metal.	clauses 3.4.2.2 & 4.1.4.11		

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5	Lowest insulation resistance being _____ MΩ (not less than 2 MΩ) measured between phases/neutral/ earth.	code 12.2.1 (Table 12-1).		
6	All metal conduit or trunking. effectively earthed with a maximum earth fault loop impedance being _____ohms.	Code 7.2		
E. Meter Board/Box				
1	No visible damage to impair safety.	code 12.1.2		
2	Safe access provided.	code 3.1.2 & clause 3.1.3.2		
3	All exposed metal parts effectively earthed and maximum earth fault loop impedance being Ω.	code 7.2.1 Code 7.2		
F. Overhead Lines				
1	No visible damage to impair Safety.	code 12.1.2		
2	A minimum height of meters from ground.	code 9.12.4		
3	Lowest insulation resistance being _____ MΩ (not less than 2 MΩ) measured between phases/ neutral/earth.	code 12.2.1 (Table 12-1).		
4	All metal work associated with every steel pole effectively earthed.	code 9.12.6		
G. Main Cables				
1	No visible damage to impair Safety.	code 12.1.2		
2	Cables protected against mechanical damage.	Codes 8.6 & 8.7, codes 8.9.6 & 12.1.2		
3	Correct phase identification provided at both ends of the cable.	Code 8.3		
4	Lowest insulation resistance being ___ MΩ (not less than 2 MΩ) measured between cores and cores to earth.	code 12.2.1 (Table 12-1)		
5	All exposed metal parts including the cable armor effectively earthed with a	code 7.2.1		

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	maximum earth fault loop impedance being _____ Ω.			
H. Distribution Board				
1	No visible damage to impair safety.	code 12.1.2.		
2	No fuse installed in the neutral circuit.	clause 7.1.6.4		
3	All live parts screened with an insulating plate or earthed metal.	clauses 3.4.2.2 & 4.1.4.11.		
4	Phase identification provided on the distribution board.	code 3.1.6		
5	Insulation resistance of not less than 2MΩ measured between phases/neutral/ earth.	Code 12.2.1 (Table 12-1).		
6	All exposed metal parts effectively earthed.	code 7.2.1		
7	A warning notice 'DANGER' provided on the front panel of every distribution board.	code 11.2.3		
8	A notice of periodic testing provided at or near the main distribution board incorporating a residual current device (RCD).	Code 11.7		
I.	**Final Circuits**			
1	No visible damage to impair safety.	code 12.1.2		
2	All non-armored cables susceptible to damage protected with steel conduit/trunking with bushing and rubber grommet provided, where necessary.	code 8.6.2		
3	Conductor sized to suit the rating of the fuse/MCB protecting the circuit.	Code 4.3.		
4	No cable joint in final circuit.	clause 8.7.1.8 of code 8.7.1		
5	All joints of metal conduits or trunking to be mechanically sound, electrically continuous and protected against corrosion.	code 8.9.2		

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6	For temporary installation, cables lying on the ground or attached to scaffoldings secured on suitable supports.	code 9.10.3		
7	Insulation resistance of not less than 2MΩ measured between phases/neutral/earth.	code 12.2.1 (Table 12-1).		
8	All metal conduits, trunking, switch boxes and exposed metal parts effectively earthed.	code 7.2.1		
9	Residual current devices function properly.	code 12.2.8		
10	Earth fault loop impedance and polarities of every outlet checked.	codes 12.2.5, 12.2.6 & 12.2.7		
J. Motors				
1	No visible damage to impair safety.	code 12.1.2.		
2	Insulation resistance of not less than 2MΩ measured between phases/neutral/earth.	code 12.2.1 (Table 12-1).		
3	All exposed conductive parts effectively earthed.	code 9.8.1		
K. Earthing				
1	No visible damage to impair safety.	code 12.1.2		
2	All exposed conductive parts of the wiring installation connected to the earthing terminal with appropriate protective conductor.	codes 7.2.1, 7.2.2 & 7.2.3.		
3	Bonding/earthing connection to water pipe/ gas pipe/duct effectively connected.	code 7.2.4		
4	A warning notice 'SAFETY ELECTRICAL EARTH CONNECTION – DO NOT REMOVE' provided at all main earthing terminal and main bonding connections.	code 11.3.1.		
5	Main equipotential bonding conductors effectively connected to main water pipes, main gas pipes, other services	codes 7.2.1 & 7.2.4		

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	pipes/ducting and exposed metallic parts of structural framework.			
6	Supplementary equipotential bonding effectively provided between exposed conductive parts and extraneous conductive parts.	codes 6.4.4, 7.2.4 and 8.7.7		
7	Exposed conductive parts of fixed equipment installed outside equipotential zone effectively earthed for the required disconnection.	code 7.3.2		
8	Exposed conductive parts of fixed equipment installed within equipotential zone effectively earthed for the required disconnection.	code 7.3.2		
9	Effectiveness of the main equi-potential bonding connection to the main earthing terminal.	clause 7.3.6.2 of code 7.3.6		
10	Effectiveness of the main equipotential bonding connection to the lighting protection system.	clause 7.3.6.2 (of code 7.3.6)		
L. Neon Sign				
1	No visible damage to impair safety.	code 12.1.2		
2	The fireman's switch clearly labelled.	clause 9.7.2.2 & code 5.2.4.		
3	All high voltage equipment enclosed in an earthed metal box fitted with a 'DANGER' warning notice.	code 11.2.1		
4	All live parts screened with an insulation plate or earthed metal.	clauses 3.4.2.2 4.1.4.11		
5	Insulation resistance of the LV circuit being ____ MΩ (not less than 2MΩ) between phases/ neutral/earth.	code 12.2.1 (Table 12-1)		
6	All exposed metalwork permanently and effectively bonded and earthed with a maximum earth fault loop	code 9.7.4 and Code 7.2		

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	impedance of _____ Ω measured at LV side.			

Checklist No. 2—Additional Items for Testing of New LV Installation

Item No.	Description of Inspection/Test	Reference code((s)/clauses for compliance	Test conducted by:	Date of Test
A. Switchboards, Circuit Breakers and Main Switches				
1	Safe access and adequate clearance space provided.	code 3.1.2 and clause 3.1.3.2		
2	Number of sources of supply: ___ and the rating of each: ___	codes 5.1.1(cl5), 6.2.2 (cl1) & 6.4.6		
3	Maximum loading approved by the service provider: _____	codes 9.13.1, 9.13.2 & 12.4.2		
4	Suitable interlock scheme provided to prevent parallel operation of two or more sources of supply.	code 5.1.1		
5	Electrically and mechanically interlocked 4-pole changeover device(s) where standby generator set(s) is installed.	clause 5.1.1.5		
6	The breaking capacity of the main switch is _____ kA and all circuit breakers/inter-connection devices are able to withstand the prospective fault current.	clause 3.1.4.8 and code 7.1.3		
7	Protective relays have been correctly set and overcurrent protective devices suitably set for all circuits.	clause 12.1.2.4(m)		
8	A means of isolation provided for every circuit.	code 5.1.1		
9	Operation of circuit breakers and main switches checked.	code 12.2.8		
10	Control, indication and alarm functions checked.	code 12.2.8		
11	No undersized conductor used	code 8.1.3		

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	between the main busbar and fuse/ MCB's.			
12	Fuses/MCB's matching the lowest rated conductor in the circuit.	Code 7.1		
13	Suitable cable terminations provided.	Code 8.7		
14	Cable conductors of correct phases connected.	clause 12.1.2.4		
15	Single-pole devices for protection or switching connected in phase conductors only.	clauses 7.1.6.4 - 7.1.6.6		
B. Busbar Trunking System including Rising Mains				
1	The current rating of the rising mains is amperes.	code 9.1.7, & Table 7-2		
2	The rising mains, lateral mains and meter boards positioned at places accessible from public area.	clause 3.1.8.9		
3	Fire barriers provided where the busbar trunking system passes through floor slabs or walls designated as fire barriers.	clause 12.1.2.4(g).		
4	Cables passing through smoke lobby protected by enclosures of adequate fire rating.	code 6.5.2		
5	Non-sheathed cables protected by conduit, trunking or ducting.	Codes 8.6 and 8.7.	.	
6	Busbar trunking systems, cables and ducting adequately supported.	code 9.2.1		
7	Armored cables properly terminated to metal casing or trunking by proper cable glands.	code 8.7.6		
8	Suitable cable lugs used for terminating cables.	Code 8.7		
9	Precaution against corrosion taking on aluminum conductor joined to copper conductor.	clause 8.7.6.9		
10	Cut-out fuses for tapping off supply fitted with insulated carriers. .	clause 9.2.4.7		
C. Overhead Lines				
1	A steel carrier wire provided between poles to prevent strain on conductor.	clauses 9.12.2, 9.12.5 & 9.12.6.		

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2	Substantial steel poles used to suspend cables crossing vehicular passes.	9.10.3.3 (b)		
3	Overhead cables supported on suitable insulators.	codes 9.12.2		
4	Suitable stay wires installed on the terminal poles and on each pole at which the line changes its direction.	codes 9.12.5		
5	Minimum clearance of overhead lines to ground, roads and obstacles maintained	code 9.12.4		
D. Main Cables				
1	The cross-sectional area or each core of the main supply cable is _____mm^2. Number of cables in parallel, if connected is _____.	Code 7.8.9 &10		
2	Armored cables properly terminated to metal casing or trunking by proper cable glands.	code 8.7.6		
3	Cables passing through smoke lobby protected by enclosures of adequate fire rating.	code 6.5.2		
4	Non-sheathed cables protected by conduit, trunking or ducting.	Codes 8.6 and 8.7		
5	Cables and ducting adequately supported in compliance with.	code 9.2.1		
6	Cables at distribution board or busbar terminated with cable lugs.	Code 8.7		
7	Main cables connected up with correct polarity.	code 12.2.5		
E. Distribution Board				
1	Safe access and adequate clearance space provided.	code 3.1.2 and clause 3.1.3.2		
2	Distribution boards securely mounted on suitable supports	code 9.2.1		
3	A suitable switch provided to control each distribution board.	code 5.1.1		
4	Phase barriers for 3-phase distribution board provided.	clause 12.1.2.4(i)ii		
5	The breaking capacity of MCB is ___kA.	Code 7.1		

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6	Suitable tools for withdrawal of fuses at a fuse board provided, where necessary.	clause 7.1.5.2		
7	Circuits connected to MCB or fuse in accordance with the schematic diagram.	code 4.2.1 (clause 4.2.1.4)		
F. Final Circuits				
1	All fuses and single pole switches connected to the phase conductors only with correct polarity.	code 12.2.5		
2	Wiring for emergency lightings and fire services installation segregated from other wirings.	code 4.5.2		
3	Low voltage circuits segregated from extra-low voltage circuits	code 4.5.2		
4	Cables of all phases and neutral of the circuit bunched and contained in the same conduit..	clause 8.5.1.6		
5	Exposed insulated non-sheathed cables protected.	Codes 8.6 and 8.7		
6	Wiring inside false ceiling protected by conduit/trunking or metallic sheath.	clause 8.6.1.6		
7	Socket outlets installed below 1.5m from floor being of shuttered type	code 8.8.4		
8	No socket outlet installed close to water tap, gas tap or cooker so as to avoid danger.	clause 8.8.5.2		
9	Floor socket outlets protected with suitable cover.	clause 8.8.5.3		
10	All socket outlets connected with protective conductors and live conductors terminated at correct terminals.	code 8.8.4		
11	Radial final circuits using 5A/15A socket outlets.	codes 4.3.5 & 9.1.1		
12	Final circuits using 13A socket outlets.	codes 4.3.4 & 9.1.1		
13	Final circuits using industrial socket outlets.	code 4.3.9		
14	Circuit protective conductor is formed by the enclosure and a separate protective conductor between the earthing terminal of	code 7.2.2		

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	socket outlet and its associated metal box provided.			
15	Circuit protective conductor is not formed by the enclosure and a separate protective conductor to the earthing terminal of socket outlet provided.	code 7.2.2		
16	Residual current device of 30 mA rated residual operating current provided for all socket outlets.	clause 9.4.2.2.		
17	Means of isolation provided for every fixed appliance.	code 5.1.1		
18	All chokes, starters and capacitors of discharge lamps enclosed in earthed metal box(es) and suitably ventilated.	code 9.7.4		
19	Phase conductors connected to the center contact of the Edison-type screw lamp holder.	code 12.2.5		
20	No switches other than a switch fed from a safety source or operated by an insulation cord or rod or a push-button type of switch having an insulated button of a large surface area provided in bathrooms.	clause 9.1.4.1		
21	Shaver supply unit complying with IEC 61558-2-5 or equivalent.	clause 9.1.4.1		
22	Socket outlet in bathroom installed beyond Zone C (i.e. 0.6m away from shower basin or bathtub) protected by an RCD with a residual operating current not exceeding 30mA or protected by an isolating transformer to IEC 61558.	clause 9.1.4.2(d).		
23	No fixed luminaire nor fixed heater having unguarded heating elements installed within reach of a person using the bath or shower.	clause 9.1.4.1		
24	All circuits supplying electrical equipment with exposed conductive parts within 2.25m height above finished floor level	clause 9.1.4.2(d)		

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	in bathroom protected by RCD having a rated residual operating current not exceeding 30mA. .			
25	Appliances exposed to weather being splashproof type.	code 8.9.2		
26	Luminaires, switches, sockets and plugs, cable couplers installed outdoor, being splashproof type.	code 8.9.2		
27	General/site lighting readily accessible to the public supplied from a safety source.	clause 9.10.3.1(b)		
28	General/site lighting not readily accessible to the public and not supplied from a safety source, protected by RCD having a rated residual operating current not exceeding 30 mA.	code 9.10.4		
G. Motors				
1	A local switch provided to control every motor.	code 5.1.3		
2	Means provided to prevent unexpected restarting of motors where such restarting might cause danger.	code 5.1.3.		
3	Flexible conduits terminated with suitable brass bushes.	clause 8.5.1.15 & 16.		
H. Earthing				
1	No gas/water pipe used as earth electrodes.	clause 7.3.4.4		
2	A test link provided at the main earthing terminal.	clause 7.3.6.4		
3	Minimum size of protective conductor used.	Table 7-3 of Code 7		
4	Protective conductor up to and including 6mm^2 with green and yellow insulation sheath used throughout its length.	clause 6.4.2.6		
5	Bonding conductors of _____mm^2 (not less than 150mm^2 copper equivalent) used for connection to the earthing terminal of the service provider's transformer(s).	clause 7.3.6.7		

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6	Bonding conductors of _____mm^2 (not less than 150mm^2 copper equivalent) used for connection to the exposed conductive parts of the service provider's underground cable(s).	clause 7.3.6.7.		
7	Copper links provided at joints of metallic trunking which forms part of a protective conductor.	code 7.2.2		
8	Separate protective conductors provided for all flexible conduits	clause 7.2.2.1		
I. Lightning Protection				
1	Air termination network/down conductor/earth termination network having good continuity.	clause 7.2.1.7 & code 9.2.6		
2	Joints and connections are mechanically and electrically sound.	clause 7.2.1.7 & code 9.2.6		
3	Connection link to the main earthing terminal provided.	clause 7.2.1.7 & code 9.2.6		
4	Test joint provided.	clause 7.2.1.7 & code 9.2.6		
5	No gas/water pipe used as earth electrodes.	clause 7.3.4.4		
6	Measured earth termination network resistance to earth not more than 10 Ohm when the connection to main earthing terminal disconnected.	clause 7.2.1.7 & code 9.2.6.		
7	No evidence of corrosion likely to lead to deterioration of the lightning protection system.	clause 7.2.1.7		
J. High Voltage Discharge Lighting (Neon Signs)				
1	_____ ampere control switch fitted with a removable handle or locking facilities	code 9.7.2		
2	Fireman's switch provided with the 'OFF' position at the top.	clause 9.7.2.2 and code 5.2.4.		
3	High voltage cables exceeding 1 meter in length for connection between lamps and transformers, being metal sheathed or armored.	code 9.7.3		
K. Warning Notices and Labels				
1	Warning notices for substations and switch rooms provided.	code 11.2.1		

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2	Warning notices for earthing and main bonding connections provided.	code 11.3.1		
3	All switchgears, distribution boards and electrical equipment properly labelled.	code 3.1.6		
Remarks: Electrical contractor and electrical professional are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of this LEWC, rather than the items as listed in the checklists only.				

LDS

Checklist No. 3— Items for Renewable Energy Power System (REPS) Installations

Installation Address:

Item No.	Description of Inspection/Test	Reference code((s)/clauses for compliance	Test conducted by:	Date of Test
A. Power Generating Equipment				
1	The solar PV panels are certified by the recognized national/ international organizations or relevant testing and certification authorities complying with relevant safety standards such as IEC 61215, BS EN 61215, IEC 61730, UL 1703 or equivalent.	code 10.1.2		
2	Other renewable energy power generating equipment (e.g. wind turbine) complies with relevant international design/safety standards.	code 10.1.2		
B. Inverter				
1	Anti-islanding function incorporated (with tripping time as required by the Service provider).	codes 10.1.2 & 10.2.4		
2	Synchronization check function incorporated (to ensure that connection of the inverter to the distribution system will only take place when the inverter output and the distribution system are operating in synchronism).	codes 10.1.2 & 10.2.4		
3	Automatic isolation function incorporated (to isolate the REPS from the distribution system automatically when fault occurs in the REPS).	codes 10.1.2 & 10.2.4		
4	Voltage and frequency regulator incorporated.	codes 10.1.2 & 10.2.4		
5	Under / Over-frequency / voltage protection function incorporated (to disconnect the inverter from the distribution system when the frequency and/or voltage of the Grid falls out of normal range).	code 10.2		
6	Auto-reconnection function	Code 10.2		

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	incorporated (to reconnect the inverter back to the distribution system when the frequency and/or voltage of the Grid resumes to normal operational range for a pre-defined period of time (with such time period to be agreed with the Service provider).			
7	Inverter are certified by the recognized national/international organizations or relevant testing and certification authorities complying with relevant safety standards such as IEC 62109, BS EN 62109, UL 1741 or equivalent.	code 10.1.2		
C. Lightning Protection				
1	Proper lightning protection systems provided for the outdoor equipment.	clause 7.2.1.7 & code 9.2.6		
D. Outdoor Installation				
1	Equipment installed outdoor being selected and erected in compliance with.	Code 8.9		
E. REPS Circuit				
1	DC protection devices provided for the circuits between renewable energy power generating equipment and inverter.	Code 7.1		
2	Inverter incorporated with isolation transformer or separated isolation transformer in compliance with IEC 61558 or equivalent provided.	code 10.1.2		
3	Pre- & post-meter lockable switches (DP / 4P) provided for isolating all sources of supply from the Grid and REPS to Renewable Energy Meter	Codes 10.1 and 10.2		
4	The earth fault loop impedance of the circuit.	Code 7.2		
5	Operation of isolators, circuit breakers and switches checked.	code 12.2.8		
6	The RCD/RCBO trip time checked. (if applicable).	code 12.2.8		
F. Earthing				
	Appropriate protective conductors effectively connected.	Code 7.2		

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G. Notice and Labels				
1	Notice displayed at the facility showing the name and registration number of the REC employed for maintaining the generating facility in continuous safe work order checked.	code 11.5.2		
2	Dual power supply warning labels displayed at all electrical equipment with dual power supply sources checked.	code 11.5.1		
3	DC warning labels displayed at DC switchgear checked.	code 11.5.1		
Remarks: Electrical contractor and electrical professional are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of this LEWC, rather than the items as listed in the checklists only				

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Checklist No. 4—Items for HV Installation

(Note: For LV Installation/Equipment, please refer to other checklists in this appendix)

Installation Address:

Item No.	Description of Inspection/Test	Reference code((s)/clauses for compliance	Test conducted by:	Date of Test
A. Switchboard, Circuit Breakers				
1	No visible damage to impair safety.	code 12.1.2.		
2	Safe access and adequate clearance space provided.	code 3.1.2 and clause 3.1.3.2		
3	Work done properly recorded in logbook.	clause 3.4.2.5 & Appendix 2		
4	Every circuit breaker provided with a legible and durable identification label.	codes 2.2.2, 3.1.6, 4.3.2 and 7.1.4		
5	An up-to-date schematic diagram displayed.	codes 3.1.6 and 4.2.1 (clause 4.2.1.4).		
6	All accessible live parts screened with insulating plate or earthed metal.	clause 3.4.2.2 and /or clause 4.1.4.11.		
7	All exposed conductive parts effectively earthed.	code 7.2.1		
8	Earthing system effectively connected.	Code 7.2		
9	Warning notice displayed at main bonding connections.	Code11.2		
10	All protective devices are functioned properly and correctly set.	code 12.2.8		
11	Padlock facilities for shutters Provided.	clause 3.4.2.5 & code 12.3.1		
12	Maintenance test carried out according to relevant recognized standards and manufacturers' recommendation, where appropriate, with test reports (insulation resistance test, pressure test, ductor test, oil dielectric strength test etc.)	code 12.3.2		
B. Main Cables				
1	No visible damage to impair safety.	code 12.1.2		

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2	Cables protected against mechanical damage and suitably supported.	Codes 8.6 and 8.7.		
3	All exposed metal parts including the armor effectively earthed.	code 7.2.1		
4	Maintenance test carried out according to relevant recognized standards and manufacturers' recommendation, where appropriate, with test reports (insulation resistance test, pressure test etc.).	code 12.3.2		
C. Transformers/Motors				
1	No visible damage to impair safety.	code 12.1.2		
2	Instructions for the treatment of persons suffering from electric shock affixed in all premises where electrical energy is generated or transformed.	clause 3.4.2.10		
3	All accessible live parts screened with insulating plate or earthed metal.	clause 3.4.2.2 and /or clause 4.1.4.11		
4	Proper ventilation provided to avoid excessive temperature rise.	codes 3.2.1 & 3.1.8		
5	Maintenance test carried out according to relevant recognized standards and manufacturers' recommendation, where appropriate, with test reports (insulation resistance test, pressure test, oil dielectric strength test etc.).	code 12.3.2		
D. Earth				
1	A warning notice ''SAFETY ELECTRICAL EARTH CONNECTION – DO NOT REMOVE' provided at all main earthing terminal and main bonding connections.	code 11.3.1		
2	Earthing conductors of adequate size.	Code 7.2		
E. Battery System				
1	Condition of battery system.			
2	Voltage of each battery cell measured.			
F. Operation and Testing Tools and Equipment				
1	Proper operation tools and			

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	equipment provided for switching and isolation use.			
2	Suitable self-test high voltage tester provided for verifying equipment dead.			
Remarks: Electrical contractor and electrical professional are required to ensure their responsible fixed electrical installation is able to comply with the relevant requirements of this LEWC, rather than the items as listed in the checklists only.				

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