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## ELECTRICAL INSTALLATION STANDARDS

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# **ELECTRICAL INSTALLATION STANDARDS**

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# ELECTRICAL INSTALLATION STANDARDS

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## CHAPTER I. GENERAL REGULATION

### Section 1. General Provisions

#### Article 1. Title and Purpose

1. The purpose of this Electrical Installation Standard is to set the technical requirements and standards for the design and installation of electrical assets and equipment in the Republic of Maldives.
2. This Standard is issued by URA under the powers vested in it by section 33 of Law No. 26/2020 (Utility Authority Act).
3. This Standard shall be cited as "Electrical Installation Standards".
4. This standard shall be effective on the date of its publication in the Government gazette.
5. Any designs or installations which deviates from this Electrical Installation Standards shall be subject to review and approval by the URA.

#### Article 2. Scope

This Electrical Installation Standards will develop the following aspects:

1. Standards for LV Electrical Installations (Outdoor and Public Areas)
2. Standards for LV Electrical Installations (In-House Areas)
3. Standards for MV Electrical Installations (Outdoor and Public Areas and Private Areas)
4. Standards for HV Electrical Installations (Outdoor and Public Areas and Private Areas)
5. Standards for Generating Stations
6. Inspection and Verification

#### Article 3. Application

This Electrical Installation Standard shall become effective from 6 calendar months from the date of the publication, and shall apply to;

1. All new electrical installations in the territory of the Republic of Maldives.
2. All Electrical Installation in the territory of the Republic of Maldives existent prior to the enactment of these Electrical Installation Standards that undergo relevant modifications, major repairs or upgrades;
3. All Electrical Installation in the territory of the Republic of Maldives existent prior to the enactment of these Electrical Installation Standards that may impose safety risks to living beings and property.

For the purposes of this Article, it is considered that relevant modifications and major repairs are those which impact at least 50% of the capacity installed at the Electrical Installation or that impact whole production lines with new circuits and power boxes, regardless of the capacity.

**Article 4. Amendments and unforeseen circumstances**

1. The URA has the authority to amend this Electrical Installation Standards and to decide on any actions with regard to conflicts of interpretation.
2. If circumstances not envisaged in the provisions of this Electrical Installation Standards or divergent interpretations of any provisions included in this Electrical Installation Standards should arise, the URA shall determine what is to be done and notify the relevant party(s), which may include service providers, licensees, and any affected party(s).
3. In assessing the results of this Electrical Installation Standards or in case of unforeseen circumstances or if any provision of this Standard should be found to be unlawful or wholly or partially invalid, the URA may amend this Electrical Installation Standards from time to time.
4. All amendments shall only be effective when it is published in the Government gazette.

**Section 2. Glossary****Article 5. Definitions**

The following definitions are to be referenced when interpreting this Electrical Installation Standards:

1.  $\Omega$ : Ohms.
2. A.: Amperes.
3. Business Day: working day, every official working day of the week according to the Republic of Maldives's regulation.
4.  $^{\circ}\text{C}$ : degree Celsius.
5. Chimney: passage or vertical channel or pipe that conducts smoke and combustion gases to the outside of a building or the part of such a structure that extends above the roof of the building.
6. daN: decaNewton.
7. DB: Distribution Board, where electrical power feed is divided into multiple circuits.
8. Distribution Network: group of assets and equipment required for the distribution of electricity in the Republic of Maldives.
9. ELCB: Earth Leakage Circuit Breaker.
10. Electric Shock: pathophysiological effect of an electric current through the human body as per IEC 60479-1.
11. Electrical Installation: group of apparatus and associated circuits designed for a particular purpose: generation, conversion, rectification, transformation, distribution or use of electric energy.
12. Generating Station: power generator or group of power generators located in a same site and their associated equipment and facilities.
13. h: hour.
14. IP: Ingress Protection rating or International Protection rating as per IEC 60529.
15. K: Kelvin.
16. km.: kilometres.

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17. Low Voltage or LV: any voltage lower than 1 kV that is normalized and approved by the URA for its use in power distribution in the Republic of Maldives.
  18. m.: metre.
  19. MEC: Maximum Export Capacity. Total electric power measured in kW for which a connection is designed to supply power from the Customer's premises to the Distribution Network.
  20. Medium Voltage or MV: any voltage from 1 kV up to 35 kV that is normalized and approved by the URA for its use in power distribution in the Republic of Maldives.
  21. MIC: Maximum Import Capacity. Total electric loading measured in kW for which a connection is designed to supply power from the Distribution Network to the Customer's premises.
  22. mm.: millimetres.
  23. N.: Newton.
  24. Operator of the Distribution Network: Service Provider in charge of the operation of the Distribution Network.
  25. PEN: Protective Earth and Neutral.
  26. PV: photovoltaic, subtype of solar-based electricity generation.
  27. Renewable Plant: Generating Station whose primary energy source qualifies as renewable energy. It notably includes wind generators and PV panels.
  28. Service Provider: agent licensed by the URA to develop activities of generation, distribution or sale of electricity or several of them in the Republic of Maldives.
  29. W.: Watt.

## Section 3. International Standards reference list

### Article 6. International Standards Reference List

1. Any mention to an International Standard in this Electrical Installation Standards refers to the latest approved and available version of the Standard or the Standard that replaces it.
2. The following International Standards are to be referenced when reading this stipulation:
  - 2.1. BS-1363: British Standard BS 1363-2 13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets.
  - 2.2. ISO 23932:2009: Fire safety engineering – General Principles.
  - 2.3. IEC 60034: Rotating electrical machines.
  - 2.4. IEC 60045: Steam turbines.
  - 2.5. IEC 60060: High voltage test techniques.
  - 2.6. IEC 60071: Insulation coordination.
  - 2.7. IEC 60073: Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators.
  - 2.8. IEC 60076: Power transformers.
  - 2.9. IEC 60183: Guide to the selection of high-voltage cables.
  - 2.10. IEC 60287: Electric cables – Calculation of the current rating.
  - 2.11. IEC 60364: Electrical Installations for Buildings.
  - 2.12. IEC 60445: Identification of conductors by colours or numerals.
  - 2.13. IEC 60447: Basic and safety principles for man-machine interface, marking and identification - Actuating principles.
  - 2.14. IEC 60449: Voltage bands for electrical installations of buildings.
  - 2.15. IEC 60479-1: Effects of current on human beings and livestock. Part 1: General aspects.
  - 2.16. IEC 60529: Degrees of Protection provided by enclosures (IP Code).
  - 2.17. IEC 60707: Flammability of solid non-metallic materials when exposed to flame sources.
  - 2.18. IEC 81346-1: Item designation in Electro technology.
  - 2.19. IEC 60826: Design criteria of overhead transmission lines.
  - 2.20. IEC 60904: Photovoltaic devices.
  - 2.21. IEC 62271: High voltage switchgear and control gear.
  - 2.22. IEC 60815: Selection and dimensioning of high voltage insulators intended for use in polluted conditions.
  - 2.23. IEC 61140: Protection against electric shock – Common aspects for installations and equipment.
  - 2.24. IEC 61400: Wind turbines.
  - 2.25. IEC 61439: Low-voltage switchgear and control gear assemblies
  - 2.26. IEC 62446: Grid connected photovoltaic systems - Minimum requirements for system documentation, commissioning tests and inspection.



## CHAPTER II. SAFETY FOR LIVING SPECIES AND GOODS

### Section 1. General Specifications

#### Article 7. Scope

The following provisions shall apply to all Electrical Installations that distribute electricity at Low Voltage, Medium Voltage and High Voltage in both public and in-house areas.

#### Article 8. Protection for safety

1. These standards contain the rules for the design and erection of Electrical Installations so as to provide safety and proper functioning for the use intended.
2. In-house Electrical Installations are required to be functional, durable, aesthetic and safe to use. Safety in Low Voltage Electrical Installation is ensured by providing protection against the following main threats:
  - 2.1. Electric shock;
  - 2.2. Thermal effects;
  - 2.3. Overcurrent; and
  - 2.4. Voltage and electromagnetic disturbances.
3. Protection against Electric Shock
  - 3.1. Persons shall be protected against dangers that may arise from contact with live parts of the installation.
  - 3.2. The protection against direct contact can be achieved by one of the following methods:
    - 3.2.1. Preventing a current from passing through the body of any person; or
    - 3.2.2. Limiting the current which can pass through a body to a value lower than the shock current.
  - 3.3. Persons shall be protected against dangers that may arise from contact with exposed-conductive parts in case of a fault. The protection against indirect contact can be achieved by one of the following methods:
    - 3.3.1. Preventing a fault current from passing through the body of any person;
    - 3.3.2. Limiting the fault current which can pass through a body to a value lower than the shock current; or
    - 3.3.3. Automatic disconnection of the supply in a determined time on the occurrence of a fault likely to cause a current to flow through a body in contact with exposed-conductive-parts, where the value of that current is equal to or greater than the shock current.

#### 4. Protection against thermal effects

- 4.1. The Electrical Installation shall be so arranged that there is no risk of ignition of flammable materials due to high temperature or electric arc.
- 4.2. In addition, during normal operation of the electrical equipment, there shall be no risk of persons suffering burns.
- 4.3. The installations shall comply with the principles of the international standard ISO 23932:2009, regarding fire safety.

#### 5. Protection against overcurrent

- 5.1. Persons shall be protected against injury and property shall be protected against damage due to excessive temperatures or electromechanical stresses caused by any overcurrent's likely to arise in live conductors. The protection can be achieved by one of the following methods:
  - 5.1.1. Automatic disconnection on the occurrence of an overcurrent before this overcurrent attains a dangerous value based on its duration and intensity;
  - 5.1.2. Limiting the maximum overcurrent to a safe value and duration.

#### 6. Protection against fault currents

Conductors, other than live conductors, and other parts intended to carry a fault current shall be capable of carrying that current without attaining an excessive temperature.

#### 7. Protection against overvoltage

- 7.1. Persons shall be protected against injury and property shall be protected against any harmful effects consequence of a fault between live parts of circuits supplied at different voltages.
- 7.2. Persons shall be protected against injury and property shall be protected against any harmful effects consequence of any excessive voltages likely to arise due to other causes (e.g. atmospheric phenomena or switching overvoltage's).

### **Article 9. Criteria for safety design of Electrical Installations**

Electrical Installations shall be designed taking into account:

- 1. The protection of persons and property in accordance with Article 8;
- 2. The proper functioning of the Electrical Installation for the use intended.
- 3. Characteristic of available supply or supplies
  - 3.1. Nature of current: a.c. and/or d.c.
  - 3.2. Nature and number of conductors:
    - 3.2.1. For a.c.: phase conductor(s)
      - 3.2.1.1. Neutral conductor;
      - 3.2.1.2. Protective conductor.
    - 3.2.2. For d.c.: conductors equivalent to those listed above.

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3.3. Values and tolerances:

- 3.3.1. Voltage and voltage tolerances;
- 3.3.2. Frequency and frequency tolerances;
- 3.3.3. Maximum current allowable;
- 3.3.4. Prospective short-circuit current.

3.4. Protective measures inherent in the supply. E.g. earthed (grounded) neutral or mid-wire.

3.5. Particular requirements of the supply undertaking.

4. Nature of demand

The number and type of the circuits required for lighting, heating, power, control, signalling, telecommunication, etc. Are to be determined by:

- 4.1. Location of points of power demand;
- 4.2. Loads to be expected on the various of demand;
- 4.3. Daily and yearly variation of demand;
- 4.4. Any special conditions;
- 4.5. Requirements for control, signalling, telecommunication, etc.

5. Emergency supply or supplies

- 5.1. Sources of supply (nature, characteristic)
- 5.2. Circuits to be supplied by the emergency source.

6. Environmental conditions

- 6.1. Typical weather conditions to be withstood by the Electrical Installation;
- 6.2. External agents that constitute a threat to the proper and safe functioning of the Electrical Installation (e.g. dust, salt, water flows, animals).

7. The cross-section of conductors shall be determined according to:

- 7.1. Their admissible maximum temperature;
- 7.2. The admissible voltage drops;
- 7.3. The electromechanical stresses likely to occur due to short-circuits;
- 7.4. Other mechanical stresses to which the conductors can be exposed; and
- 7.5. The maximum impedance with respect to the functioning of the short-circuit protection.
- 7.6. The demand load.

## 8. Type of wiring and methods of installation

The choice of type of wiring and the methods of installation shall be selected attending to:

- 8.1. The nature of the location;
- 8.2. The nature of the walls or other parts of the building supporting the wiring;
- 8.3. Accessibility of wiring to persons;
- 8.4. The voltage level;
- 8.5. The electromechanical stresses likely to occur due to short-circuits; and
- 8.6. Other stresses to which the wiring can be exposed during the erection of the Electrical Installation or in service.

## 9. Protective equipment

The characteristic of protective equipment shall be determined with respect to their function which may be, e.g., protection against the effects of:

- 9.1. Overcurrent (overload, short-circuit);
- 9.2. Earth-fault current;
- 9.3. Overvoltage; or
- 9.4. Under voltage and no-voltage.

The protective devices shall operate at values of current, voltage and time suitably related to the characteristics of the circuits and to the possible sources of danger.

## 10. Emergency control

Where, in case of danger, there is necessity for immediate interruption of supply, an interrupting device shall be installed in such a way that it can be easily recognized and effectively and rapidly operated.

## 11. Disconnecting devices

Disconnecting devices shall be provided so as to permit disconnection of the Electrical Installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.

## 12. Prevention of mutual influence

The Electrical Installation shall be arranged in such a way that no mutual detrimental influence will occur between the Electrical Installation and non-electrical installations of the building.

## 13. Accessibility of electrical equipment

The electrical equipment shall be arranged so as to afford as may be necessary:

- 13.1. Sufficient space for the initial installation and later replacement of individual items of electrical equipment; and
- 13.2. Accessibility for operation, testing, inspection.
- 13.3. Erection, maintenance, and repair.

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## Section 2. Protection for Safety

### Article 10. Protection of persons against Electric Shock

1. As a general rule, hazardous-live elements of an Electrical Installation shall not be accessible to persons<sup>1</sup> and accessible elements shall not be hazardous live.
2. Live parts of Electric Installations shall be protected by barriers and enclosures to impede direct contact of persons with live parts.
3. All conductive (which in general means metallic) cases and enclosures of live elements in an Electric Installation shall be connected to the protective earth system of the installation.
4. The protective earth system of an Electric Installation shall ensure that there is a path to earth for the currents in metallic cases and enclosures with lower resistance than that of the human body as per IEC 61140 and IEC 60364.
5. Electrical Installations shall be equipped with residual current protection equipment which shall disconnect the power supply to the Electrical Installation to prevent Electric Shocks as per IEC 61140 and IEC 60364.
6. Live parts at a voltage higher than 25 V. a.c. rms or 60 V. ripple-free<sup>2</sup> d.c. shall be protected against direct contact by means of:
  - 6.1. Barriers or enclosures affording a degree of protection of at least IP65 of IEC 60529, or
  - 6.2. Insulation capable of withstanding a test voltage of 1000 V. a.c. rms for one (1) minute.
7. Protection against direct contact shall be granted by means of any of the following solutions:
  - 7.1. Insulation of live parts; which can only be removed by destruction.
  - 7.2. Protection by barriers or enclosures of at least degree of protection IP2X. Horizontal top surfaces of barriers or enclosures which are readily accessible shall have a degree of protection of at least IP4X of IEC 60529. Barriers and enclosures shall not be opened or removed but with the aid of a specific tool or key, after disconnection of the supply to live parts or where a protection barrier providing protection of at least IP2X of IEC 60529 prevents contacts with live parts.
  - 7.3. Protection by obstacles; which prevent unintentional contact with live parts and unintentional bodily approach to live parts. Obstacles may be removed without using a key or tool but shall be secured to prevent unintentional removal.
  - 7.4. Protection by placing out of reach: simultaneously accessible parts at different potential shall be placed at least 2.50 m. apart.

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<sup>1</sup> Authorized and skilled personnel may be allowed to access those elements via specific procedures.

<sup>2</sup> Sinusoidal voltage content of not more than 10% r.m.s.; that means a maximum peak value not exceeding 70 V. for a nominal 60 V. system.

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- 7.5. Residual current devices with a rated operating residual current not exceeding 30 mA are authorized as additional protection devices in case of failure of main protection devices against direct contact but they cannot constitute the unique protection method.
  8. Protection against indirect contact shall be granted by means of any of the following solutions:
    - 8.1. Automatic disconnection of supply shall be applied in the event of a fault between a live part and an exposed conductive part or a protective conductor in the circuit or equipment ensuring that a touch voltage exceeding 50 V. a.c. or 120 V. ripple-free d.c. does not persist to cause a risk of harmful physiological effect in a person in contact with simultaneously accessible conductive parts.
    - 8.2. Earthing. Exposed conductive parts shall be connected to a protective conductor as specified for each type or earthing arrangement according to IEC 60364-5-54. Exposed conductive parts shall be connected to the same earthing system individually, in groups or collectively.
  9. Protection against faults shall be granted by combination of the following solutions:
    - 9.1. Protective-equipotential-bonding which shall comply with the requirements of IEC 61140.
    - 9.2. Protective screens, interposed between hazardous-live parts of an Electrical installation, system or equipment and the part being protected shall be connected to the protective-equipotential-bonding system of the installation, system or equipment and comply with the requirements of IEC 61140.
    - 9.3. Automatic disconnection of supply.

#### **Article 11. Protection of persons against thermal effects**

1. Persons, fixed equipment, and fixed materials adjacent to electrical equipment shall be protected against harmful effects of heat development by electrical equipment, or thermal radiation, particularly the following effects:
  - 1.1. Combustion or degradation of materials;
  - 1.2. Risk of burns; and
  - 1.3. Impairment of the safe function of installed equipment.
2. Electrical equipment shall not present a fire hazard to adjacent materials.
3. Where fixed equipment may attain surface temperatures which could cause a fire hazard to adjacent materials, the equipment shall either:
  - 3.1. Be mounted on or within materials which will withstand such temperatures and are of low thermal conductance, or
  - 3.2. Be screened from elements of building construction by materials which will withstand such temperatures and are of low thermal conductance, or
  - 3.3. Mounted to allow safe dissipation of heat at a sufficient distance from any material on which such temperature could have deleterious thermal effects, any means of support being of low thermal conductance.

4. Where areas or sparks may be emitted by permanently connected equipment in normal service, the equipment shall either:
  - 4.1. Be totally enclosed in arc-resistant material, or
  - 4.2. Be screened by arc-resistant material from building elements on which the arcs could have deleterious thermal effects, or
  - 4.3. Be mounted to allow safe extinction of the arc at a sufficient distance from building elements on which the arc could have destructive thermal effects.

Arc-resistant material used for this protective measure shall be non-combustible, of low thermal conductivity, and of adequate thickness to provide mechanical stability.

5. Fixed equipment causing a focus or concentration of heat shall be at a sufficient distance from any fixed object or building element so that the object or element, in normal conditions, cannot be subjected to a dangerous temperature.
6. Wherever electrical equipment in a single location contains flammable liquid in significant quantity, precaution shall be taken to prevent burning liquid and products of combustion of the liquid (flame, smoke, toxic gases) spreading to other parts of the building.
7. The material of enclosures arranged around electrical equipment during erection shall withstand the highest temperature likely to be produced by the electrical equipment.
8. Forced air heating system shall be such that their 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 stopped. In addition, they shall have two temperature limiting devices independent of each other which prevent permissible temperatures from being exceeded in air ducts. The frame and enclosure of heating elements shall be of non-combustible material.
9. All appliances producing hot water or steam shall be protected by design or erection against overheating in all service conditions. Unless the appliances comply as a whole with the appropriate IEC standards, the protection shall be by means of an appropriate non-self-resetting device, functioning independently of the thermostat. If an appliance has no free outlet, it shall also be provided with a device which limits the water pressure.

## **Article 12. Protection of Electrical Installations from the effects of overcurrents**

1. Live conductors shall be protected by one or more devices for automatic interruption of the supply in the event of overload and short circuits except in case where the overcurrent is limited.
2. Devices ensuring protection against both overload current and short-circuit current shall be capable of breaking any overcurrent up to and including the prospective short-circuit current at the point where the device is installed. Such protective devices may be:
  - 2.1. Circuit breakers incorporating overload release;
  - 2.2. Circuit breakers in conjunction with fuses;
3. Devices ensuring protection against overload current only generally are inverse-time-lag protective devices whose interrupting capacity may be below the value of the prospective short-circuit at the point where devices are installed.

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4. Devices ensuring protection against short-circuit current only may be installed where overload protection is achieved by other means or where overload protection allows to be dispensed with. The devices shall be capable of breaking short-circuit current up to and including the prospective short-circuit current. Such devices may be:
    - 4.1. Circuit breakers with short-circuit release;
    - 4.2. Fuses.
  5. Protective devices against overload current shall be provided to break any overload current flowing in the circuit conductors before such a current could cause a temperature rise detrimental to insulation, joints, termination, or surrounding of the conductors.
  6. The operating characteristic of a device protecting a conductor against overload shall satisfy the two following conditions:
    - 6.1.  $I_B \leq I_n \leq I_Z$ ;
    - 6.2.  $I_2 \leq 1.45 \cdot I_Z$ ;

Where:

$I_B$  = current for which the circuit is designed;

$I_Z$  = continuous current-carrying capacity of the cable or busbar or bus terminal;

$I_n$  = nominal current of the protective device;

$I_2$  = current ensuring effective operation of the protective device; in practice  $I_2$  is taken as equal to:

    - The operating current in conventional time for circuit breakers;
    - The fusing in conventional time for type gI fuses as per IEC 60364;
    - 0.9 times the fusing current in conventional time for type gII fuses as per IEC 60364.
  7. Protective devices against short-circuit currents shall be provided to break any short-circuit current flowing in the circuit conductors before such a current could cause danger due to thermal and mechanical effects produced in conductors and connections.
  8. The prospective short-circuit current at every relevant point of installation shall be determined. This may be done either by calculation or by Measurement.
  9. Each short-circuit protective device shall meet both of the following conditions:
    - 9.1. The breaking capacity shall be not less than the prospective short-circuit current at the place of its installation, except where the following paragraph applies.
    - 9.2. A lower breaking capacity is admitted if another protective device having the necessary breaking capacity is installed on the supply side. In that case, the characteristic of the devices must be coordinated so that the energy let through by these two devices does not exceed that which can be withstood without damage by the device on the load side and the conductors protected by these devices.
  10. All current caused by a short circuit occurring at any point of the circuit shall be interrupted in a time not exceeding that which brings the conductors to the admissible limit temperature.



11. For short circuits of duration up to 5s, the time  $t$  in which a given short-circuit current will raise the conductors from the highest admissible temperature in normal duty to the limit temperature can as an approximation be calculated from the formula:

$$\sqrt{t} = k \cdot \frac{S}{I}$$

Where:

$t$  = duration in seconds;

$S$  = cross-sectional area in square millimetres;

$I$  = effective short-circuit current;

$K$  =

- 115 for copper conductors insulated with PVC;
- 135 for copper conductors insulated with general purpose rubber, butyl rubber, cross-linked polyethylene and ethylene propylene rubber; and
- 115 for tin-soldered joints in copper conductors, corresponding to temperature of 160 °C

**Article 13. Protection of Electrical Installations from the effects of voltage and electromagnetic disturbances**

1. At the transformer substations shall be an earthing system to which shall be connected:
  - 1.1. Earth electrodes;
  - 1.2. The transformer tank;
  - 1.3. Metallic coverings of MV cables;
  - 1.4. Metallic coverings of LV cables except where the neutral conductor is earthed via a separate earth electrode;
  - 1.5. Earth wires of MV systems;
  - 1.6. The exposed conductive parts of MV and LV equipment; and
  - 1.7. Extraneous conductive parts present in the Electrical Installation.
2. The transformer substation shall be connected to cables with suitable earthed metallic coverings, whether MV cables, LV cables or a combination of both. The total length of these cables shall not exceed 1 km.
3. The earthing resistance of the exposed conductive parts of the transformer substation shall not exceed 1  $\Omega$ .
4. The earthing system of the installation shall be of type TN, TT or IT and comply with the requirements of IEC 60364-4-44.
5. Equipment shall have at least an impulse withstand voltage as indicated in Table 44B of IEC 60364-4-44, as shown in the following table:

**Table 1 – Required impulse withstand voltage for equipment**

Nominal voltage of the installation <sup>a</sup> V		Required impulse withstand voltage for kV			
Three-phase systems <sup>b</sup>	Single-phase systems with middle point	Equipment at the origin of the installation (impulse withstand category IV)	Equipment of distribution and final circuits (impulse withstand category III)	Appliances (impulse withstand category II)	Specially protected equipment (impulse withstand category I)
—	120-240	4	2,5	1,5	0,8
230/400 <sup>b</sup> 277/480 <sup>b</sup>	—	6	4	2,5	1,5
400/690	—	8	6	4	2,5
1 000	—	Values subject to system engineers			

<sup>a</sup> According to IEC 60038.

<sup>b</sup> In Canada and USA for voltages to earth higher than 300 V, the impulse withstand voltage corresponding to the next higher voltage in column one applies.

Category I is addressed to particular equipment engineering.

Category II is addressed to product committees for equipment for connection to the mains.

Category III is addressed to product committees of installation material and some special product committees.

Category IV is addressed to supply authorities and system engineers (see also 443.2.2).

6. Protection against overvoltages due to atmospheric conditions shall be provided for those Electrical Installation that include or are supplied from aerial lines, by the installation of:
- 6.1. A surge protection device with a protection level of category II in accordance with IEC 60364-5-53; or
  - 6.2. By other Means providing at least an equivalent attenuation of overvoltages.

## **CHAPTER III. STANDARDS FOR LV ELECTRICAL INSTALLATIONS (OUTDOOR AREAS AND PUBLIC AREAS)**

### **Section 1. General Specifications**

#### **Article 14. Scope**

The following provisions shall apply to all Electrical Installations that distribute electricity at low voltage (up to 1,000 V) in outdoor areas and public areas.

All LV distribution cables shall be installed underground. Overhead installations will be allowed only after obtaining a special permit issued by the URA.

#### **Article 15. Standard voltage levels**

1. Although any voltage level up to 1,000 V is considered low voltage, the standard voltage level for LV Electrical Installation shall be:
  - 1.1. 230 V phase-to-neutral and 400 V phase-to-phase for 4-wire 3-phased networks.
2. The use of voltage levels other than the standard voltage levels here presented shall be authorized by the URA.

### **Section 2. Standards for LV overhead lines in outdoor areas and public areas**

#### **Article 16. Conductors**

1. All conductors used in LV overhead lines shall be made in copper and shall be insulated. Aluminum will not be accepted.
2. Insulated conductors shall:
  - 2.1. Be of nominal voltage not lower than 0.6/1 kV and have an insulation covering that grants adequate resistance to open air weather conditions, in particular salty and sunny environments.
  - 2.2. Have a cross section of at least 10 mm<sup>2</sup> except for drop-offs that shall have a cross section of at least 6 mm<sup>2</sup> for connection no larger than 40A.
3. Bare conductors shall:
  - 3.1. Be insulated for a nominal voltage not lower than 0.6/1 kV and be prepared to resist open air weather conditions, in particular salty environments.
  - 3.2. Have a maximum tensile strength of at least 410 daN.
  - 3.3. Not be installed in areas with trees or with fire hazard.
4. Conductors can be installed on support structures such as poles or fixed to walls or facades.
5. Support or guiding wires shall be made in galvanized steel with a tensile breaking stress of at least 800 daN.

6. The neutral conductor shall not be interrupted except by omnipolar switches and disconnectors that connect and disconnect all phases and the neutral at the same time or that connect the neutral first and disconnect the neutral last. The neutral conductor can also be interrupted in removable joints in the neutral in the proximity of phase conductors' switches or disconnectors subject to being adequately signalled and requiring a tool for its operation.
7. The neutral conductor shall be earthed in the low voltage side of the transformer station or the Generating Station that supplies the circuit.
8. The neutral conductor in TT and TN systems and the protective earth conductor in TN-S systems shall be earthed every 500 m. of line.

#### **Article 17. Fittings and accessories**

1. Fittings and accessories installed in LV overhead lines in outdoor areas and public areas shall be adequately protected against corrosion and ageing and shall resist the mechanical efforts to which they may be exposed with a security coefficient of at least that of the anchoring device to which they are connected.
2. Stays shall be metallic rods or wires protected against corrosion and with a minimum maximum tensile strength of 1,400 daN.
3. Stays shall be anchored to the ground through metallic, concrete or wood anchors or anchors made in any other material capable of withstanding the mechanical efforts to which they will be exposed and protected against outside weather conditions, in particular salty environments.

#### **Article 18. Insulators**

1. Insulators shall be made in porcelain, glass or other materials of equivalent resistance insulating, weather resistance (in particular resistance to salty environments) and mechanical resistance as porcelain and glass insulators.
2. Insulators shall be installed fixing them to the support structures or walls by means of threaded mechanisms or cementation with substances that do not damage any of the parts in contact with it and which do not suffer volumetric variations that can impact the insulators or the safety of the installation.

#### **Article 19. Support structures**

1. Support structures shall be made in metal, concrete or wood.
2. Support structures shall be protected against outside weather conditions (in particular against salty environments) either by themselves or by means of protective coverings or treatments (such as galvanizing).
3. The foundations of support structures shall be adequate to the load supported by the structure and be calculated taking into account the weight of the foundation itself.

#### **Article 20. Mechanical calculations**

1. In the mechanical calculations of the elements of LV overhead lines, the following loads shall be taken into account:
  - 1.1. The own weight of the elements, as a vertical load;

- 1.2. Overloads due to wind pressure, as a load perpendicular to the length of the line, unless in those cases where the wind constantly blows in parallel to the direction of the line. The wind overload shall take the following values:
  - 1.2.1. On conductors: 50 daN/m<sup>2</sup>;
  - 1.2.2. On flat surfaces : 100 daN/m<sup>2</sup>;
  - 1.2.3. On cylindrical surfaces of support structures: 70 daN/m<sup>2</sup>.
2. Support structures shall be designed to have a security coefficient between its tensile strength and its maximum tensile strength or breaking stress of at least 2.5 when under the worse loading conditions foreseen (loads, overloads and temperature).
3. The maximum drag of conductors shall be calculated under the maximum loading conditions foreseen (loads and overloads) at a temperature not lower than 50 °C.
4. Support structure shall be calculated for supporting their own load and the loads of the elements there connected, including the stress case where one of the conductors connected breaks. The minimum breaking stress security coefficients for support structures shall be:

**Table 2 – Minimum breaking stress security coefficients for structures of LV overhead lines**

Support structure material	Security coefficient
Metal	1.5
Vibrated reinforced concrete	2.5
Wood	3.5
Other non-metallic materials	4.5

#### **Article 21. Electrical calculations**

1. The maximum current in bare copper conductors in steady operation shall not be higher than the values in the following table:

**Table 3 – Maximum current density for conductors of LV overhead lines**

Conductor's cross section (in mm <sup>2</sup> )	Current density (A/mm <sup>2</sup> )
10	8.75
16	7.60
25	6.35
35	5.75
50	5.10
70	4.50
95	4.05

2. The maximum current in insulated copper conductors in steady operation shall be calculated based on the following base case for open air installations with an ambient temperature of 40 °C:

**Table 4 – Maximum current in insulated copper conductors in steady operation of LV overhead lines**

Number of conductors times cross section (in mm <sup>2</sup> )	Maximum current (A)	
	Laying or fixed on walls or facades	Laid with steel support wire
2x10	77	85
4x10	65	72
4x16	86	95

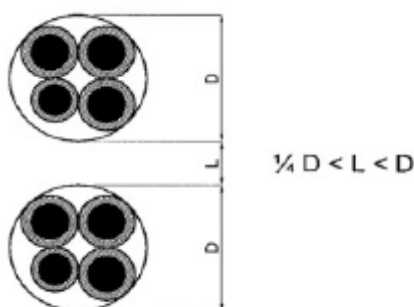
3. Correction factors for insulated cables:

- 3.1. In case of insulated conductors directly exposed to solar irradiation, a correction factor of 0.9 shall be applied to all admissible maximum currents to take into account the surface heating of the cable.
- 3.2. In case insulated cables are grouped the following correction factor shall be applied to take into account the deteriorated ventilation (assuming distance between cables, L, longer than a quarter of the diameter of the cables and shorter than a diameter):

**Table 5 – Correction factors for insulated cables in LV overhead lines**

Number of cables	1	2	3	More than 3
Correction factor	1.00	0.89	0.80	0.75

**Figure 1 – Scheme of the assumed distances between insulated cables for the application of correction factors in LV overhead lines**



4. The maximum short-circuit current admissible in insulated LV cables shall depend on the cross section of the conductors and the length of the short-circuit as per the following table, Measured in kA:

**Table 6 – Maximum short-circuit current admissible in insulated LV cables by conductor's cross section and length of the short-circuit**

Conductor's cross section (in mm <sup>2</sup> )	Length of the short-circuit (in seconds)								
	0.1	0.2	0.3	0.5	1.0	1.5	2.0	2.5	3.0
10	4.81	3.29	2.70	2.11	1.52	1.26	1.11	1.00	0.92
16	7.34	5.23	4.29	3.35	2.40	1.99	1.74	1.57	1.44

**Article 22. Minimum installation distances**

1. Insulated conductors shall be installed in a way such that the lowest point is at least 2.5 m. over ground level.
2. Bare conductors shall be installed in a way such that the lowest point is at least 6 m. over ground level.
3. Conductors shall be installed with minimum separation distances of at least:
  - 3.1. 0.30 m from the upper side of windows;
  - 3.2. 0.50 m from the lower side of windows;
  - 3.3. 0.05 m from metallic elements present in facades, unless specifically protected for that purpose;
  - 3.4. 0.30 m from the upper side of balconies; and
  - 3.5. 1.00 m from the lower side of balconies.
4. The minimum distance between bare conductors and between these and buildings' walls shall be at least:
  - 4.1. 0.10 m. for spans of up to 4 m.;
  - 4.2. 0.15 m. for spans of between 4 and 6 m.;
  - 4.3. 0.20 m. for spans of between 6 and 30 m.; and
  - 4.4. 0.30 m. for spans of between 30 and 50 m.
  - 4.5. For spans longer than 50 m. the minimum distance shall be obtained with the following formula:

$$D = 0.55 \cdot \sqrt{\text{sag in metres}}$$

5. Conductors attached to walls and facades shall have a minimum distance of 0.20 m. between them.

6. Where a LV overhead lines crosses a MV overhead lines, the LV line shall pass under that of MV at a distance of at least:

$$d = 1.5 + \frac{U + L1 + L2}{100}$$

Where:

- U = nominal voltage, in KV, of the MV line;
  - L1 = Length, in m., between the crossing point and the nearest MV line support structure;
  - L2 = Length, in m., between the crossing point and the nearest LV line support structure.
7. Where two bare conductor LV overhead lines cross, the minimum distance between them shall be 0.50 m. in general; unless the crossing takes place at a support structure, then the minimum distances set in Point 4 of this Article shall apply.
8. Where a bare conductor LV overhead line crosses a telecommunications line, the former shall pass above the latter. The minimum distance between them shall be 0.50 m.
9. Where a LV overhead line crosses over navigable water, the lowest point of the line shall be at least 2 m. over the maximum height over water of the boats authorized to pass there.
10. Where a LV overhead line crosses a water, fuel or gas pipe, the minimum distance between them shall be 0.50 m for insulated conductors and 1.5 m. for bare conductors. Joints in the line or in the pipe shall be at least 1 m. away from the crossing point.
11. Where a LV overhead line runs parallel to a MV overhead line, the minimum distance between them shall be equal to 1.5 times the height of the highest support structure of any of the lines. Exceptions to this rule are access lines for Generating Stations, transformer substations and distribution transformers.
12. Where two LV overhead lines run in parallel, the minimum distance between them shall be 0.50 m in case of insulated conductors and 1 m. in case any of them has bare conductors.
13. Where LV overhead lines run in parallel to roads or ways, the minimum distance between the road or way and the overhead line shall be 6 m. in case vehicles circulate on the road. In case vehicles do not circulate on the road or way, the minimum distance can be reduced to 5 m. for bare conductors and 4 m. for insulated conductors.
14. The minimum distance between LV overhead lines and water, fuel and gas pipes shall be 0.20 m and 1 m. from joints. The minimum distance shall be increased to 1 m. in case of important fuel or gas pipes.



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## **Section 3. Standards for LV underground cables in outdoor areas and public areas**

### **Article 23. Conductors**

1. LV conductors used in underground installations in outdoor areas and public areas shall be made in copper and be insulated with appropriate polymeric compounds. Aluminium conductors will not be accepted.
2. LV underground cables shall be protected against corrosion and shall have the mechanical strength required to withstand any effort that they are reasonably expected to suffer.
3. Cables can be of one or more conductors and be of nominal voltage not lower than 0.6/1 kV.
4. The cross section of conductors used in LV underground cables shall be adapted to the currents and voltage drops foreseen and, in any case, not smaller than 6 mm<sup>2</sup>
5. The neutral conductor shall have a cross section Equal to that of the phase conductors for cables with two, three or four conductors.
6. Conductor routing shall be made as straight as possible, observing the minimum curve radius recommended by the manufacturer and, whenever possible, in parallel with building facades, roads, ways and sidewalks.

### **Article 24. Installation of underground cables**

1. Underground cables shall be installed:
  - 1.1. In public terrain where possible;
  - 1.2. In a path as straight as possible, in parallel with the main surrounding buildings' facades where possible;
  - 1.3. With clear indications, at each accessible point, of the hazardous nature of the cable; and
  - 1.4. Observing the minimum cable bend radius as set by the manufacturer.
2. Underground cables can be either:
  - 2.1. Directly buried cables; or
  - 2.2. Cables in duct.
3. Directly buried cables:
  - 3.1. Shall be buried so that the upper border of the cable is at least 1 m. below the surface if under a sidewalk or at least 0.8 m. if under a road.
  - 3.2. Lower deepness can be accepted if the cable is adequately equipped with additional mechanic protections.
  - 3.3. A layer of at least 10 cm. of sand or material of similar characteristics shall be deposited immediately over the cable, free of extraneous bodies

- 
- 3.4. The sides of the trench shall be stable and not present rockfall risk.
  - 3.5. In order to avoid damage due to excavations made by third parties, cables shall be mechanically protected to withstand a point impact of 20 J of energy. The mechanical protection shall cover the plan projection of the cable.
  4. Cables in duct:
    - 4.1. Shall be buried so that the upper border of the duct is at least 0.6 m. below the surface if under a sidewalk or at least 0.8 m. if under a road.
    - 4.2. Ducts where the cable is installed shall be made in synthetic material, cement and derivatives or in metal subject to withstand the necessary mechanical efforts.
    - 4.3. The inner diameter of the duct shall not be less than 1.5 times the diameter of the cable or of the apparent diameter of the set of cables in case several cables are installed in the same duct.
    - 4.4. The interior of the duct shall be smooth so as to facilitate the installation and removal of the cables.
    - 4.5. No more than one circuit of cables shall be installed per duct.
    - 4.6. In case a single single-pole cable is installed in a duct, the duct shall be made in non-ferromagnetic material.
    - 4.7. The deployment of the duct shall avoid bend ratios smaller than those recommended by the manufacturer of the cable.
    - 4.8. Inspection chambers shall be installed at each end of the cable. Intermediate inspection chambers at least every 40 m.
  5. Where the current to be wheeled is higher than that admissible by a single cable, several conductors per phase are allowed subject to the following requirements:
    - 5.1. Use conductors of the same model, material, section and length; and
    - 5.2. Cables shall be grouped symmetrically staggered in one or several levels.

#### **Article 25. Electrical calculations**

1. Electrical calculations shall be made to obtain the electrical parameters, maximum currents, voltage drops and power losses associated to the LV underground cable under all foreseen operation modes in order to avoid overshooting the maximum temperature for the cable.
2. The maximum current admissible during steady operation shall depend on the maximum temperature the insulation of the cable is able to withstand without deteriorating its electrical, mechanical or chemical properties. Maximum temperatures for cables with dry insulation are those indicated in the following table or as indicated by the manufacturer:



**Table 7 – Maximum temperature for underground cables with dry insulation**

Type of dry insulation	Steady operation ( $\Theta_s$ in °C)	Short-circuit no longer than 5 seconds ( $\Theta_{sc}$ in °C)
Polyvinylchloride (PVC)	70	160
Crosslinked Polyethylene (XLPE)	90	250
Ethylene Propylene (EPR)	90	250

### 3. Directly buried installations

- 3.1. The maximum current in steady operation shall be determined based on the base installation: dry insulation installation of a single two-pole cable or two single-pole cables in contact, directly buried in all their length in a trench at 0.70 m. deep, in a soil with average thermal resistivity equal to 1 K.m./W., with an average soil temperature at the mentioned depth of 25 °C and temperature at that deepness of 25 °C.
- 3.2. The calculation of the maximum current shall be adapted to each particular situation to ensure that the maximum temperature generated by the calculated current is not higher than the one stipulated in Point 2 of this Article.
- 3.3. Maximum steady operation current (A.) for the base installation with copper conductor as per standard IEC 60364-5-52:

**Table 8 – Maximum steady operation current by type of LV directly buried underground cable**

	Triplet of single-pole cables*			3-pole cable		
Cross section (mm <sup>2</sup> )						
	Insulation type					
	XLPE	EPR	PVC	XLPE	EPR	PVC
6	72	70	63	66	64	56
10	96	94	85	88	85	75
16	125	120	110	115	110	97
25	160	155	140	150	140	125
35	190	185	170	180	175	150
50	230	225	200	215	205	180
70	280	270	245	260	250	220
95	335	325	290	310	305	265

\*Including the neutral conductor, if any

3.3.1. In the case of two single-pole cables, the maximum current of the above table for the triplet of single-pole cables table shall be increased by a corrective factor of 1.225.

3.3.2. In the case of a 2-pole cable, the maximum current of the above table for the 3-pole cable shall be increased by a corrective factor of 1.225.

#### 4. Correction factors for buried cables

##### 4.1. Correction for soil temperature

4.1.1. Where the average temperature of the soil is different than 25 °C, the following correction factor F shall be applied to direct buried cables depending on the maximum temperature for the conductor ( $\Theta_s$ ) as per IEC 60364-5-52:

**Table 9 – Correction factor F for direct buried LV cables depending on the maximum temperature for the conductor and the soil temperature**

$\Theta_s$ (°C)	Soil temperature ( $\Theta_t$ in °C)								
	10	15	20	25	30	35	40	45	50
105	1.09	1.06	1.03	1.00	0.97	0.94	0.90	0.87	0.83
90	1.11	1.07	1.04	1.00	0.96	0.92	0.88	0.83	0.78
70	1.15	1.11	1.05	1.00	0.94	0.88	0.82	0.75	0.67
65	1.17	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61

4.1.2. The correction factor F for temperatures other than those in the table shall be:

$$F = \sqrt{\frac{\theta_s - \theta_t}{\theta_s - 25}}$$

##### 4.2. Correction for soil thermal resistivity

4.2.1. Where the thermal resistivity of the soil is different than 1 K.m./W., the following correction factor shall be applied as per IEC 60364-5-52:

**Table 10 – Correction factor for soil thermal resistivity for LV directly buried underground cables**

Type of cable	Soil's thermal resistivity (K.m./W.)										
	0.8	0.85	0.90	1.00	1.10	1.20	1.40	1.65	2.0	2.5	2.80
Single-pole	1.09	1.06	1.04	1	0.96	0.93	0.87	0.81	0.75	0.68	0.66
3-pole	1.07	1.05	1.03	1	0.97	0.94	0.89	0.84	0.78	0.71	0.69

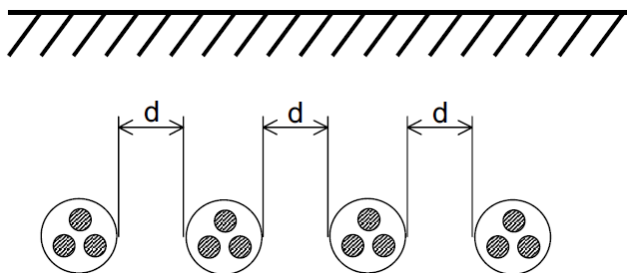
#### 4.3. Correction for composition of the cable

- 4.3.1. Where there are more than one 3-pole cable or more than one triplet of single pole cables the following correction factors shall be applied depending on the number of those 3-pole cables or triplets and the distances between them, as per IEC 60364-5-52:

**Table 11 – Correction factors for composition of the cable in directly buried LV underground cables**

Distance between cables or triplets (d, in m.)	Number of cables or triplets in the trench or duct							
	2	3	4	5	6	8	10	12
In contact (d = 0)	0.80	0.70	0.64	0.60	0.56	0.53	0.50	0.47
0.07	0.85	0.75	0.68	0.64	0.60	0.56	0.53	0.50
0.10	0.85	0.76	0.69	0.65	0.62	0.58	0.55	0.53
0.15	0.87	0.77	0.72	0.68	0.66	0.62	0.59	0.57
0.20	0.88	0.79	0.74	0.70	0.68	0.64	0.62	0.60
0.25	0.89	0.80	0.76	0.72	0.70	0.66	0.64	0.62

**Figure 2 – Scheme of distribution of directly buried LV underground cables**



#### 4.4. Correction for depth different than 0.70 m.

- 4.4.1. Where there cables are buried at depths different than 0.70 m. the following correction factors shall be applied as per IEC 60364-5-52:

**Table 12 – Correction factors for depth of directly buried cables different than 0.70 m.**

Depth (m.)	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.20
Correction factor	1.03	1.02	1.01	1.00	0.99	0.98	0.97	0.95

#### 5. Cables in duct

- 5.1. The maximum current in steady operation for LV underground cables installed in ducts shall be calculated based on the maximum current for directly buried cables corrected by the following factors:

- 5.1.1. In case a line has a 3-pole cable or a triplet of single-pole cables inside the same duct, a correction factor of 0.8 shall be applied;

- 5.1.2. In case a line has four single-pole cables placed in four separate ducts, a correction factor of 0.9 shall be applied;
- 5.1.3. Where the length of the section of cable installed in duct is not longer than 15 m. and the duct is filled with special agglomerates, no correction factor shall be required and the maximum currents for directly buried cables shall apply.
- 5.1.4. Other cases and cable configuration shall be analyzed on a case per case basis so that the maximum temperature in the cable does not overshoot the maximum temperature by type of insulator defined in Point 2 of this Article.

## 6. Open air installations

- 6.1. The maximum current in steady operation shall be determined based on the base installation: dry insulation installation composed of a single 3-pole or 4-pole cable or triplet of single-pole cables in contact, deployed in a way that allows good airflow, protected from the sun and with ambient air temperature of 40 °C.
- 6.2. The calculation of the maximum current shall be adapted to each particular situation to ensure that the maximum temperature generated by the calculated current is not higher than the one stipulated in Point 2 of this Article.
- 6.3. Maximum steady operation current (A.) for the base installation with copper conductor as per IEC 60364-5-52:

**Table 13 – Maximum steady operation current for the base installation with copper in open air LV cable installation**

Cross section (mm <sup>2</sup> )	Triplet of single-pole cables*			3-pole cable		
	Insulation type			Insulation type		
	XLPE	EPR	PVC	XLPE	EPR	PVC
6	46	45	38	44	43	36
10	64	62	53	61	60	50
16	86	83	71	82	80	65
25	120	115	96	110	105	87
35	145	140	115	135	130	105
50	180	175	145	165	160	130
70	230	225	185	225	220	165
95	285	280	235	260	250	205

\*Including the neutral conductor, if any

## 6.4. Correction factors for open air installations

### 6.4.1. Correction for air temperature

- a) Where the average temperature of the air is different than 40 °C, the following correction factor F shall be applied to direct buried cables depending on the maximum temperature for the conductor ( $\theta_s$ ), as per IEC 60364-5-52:

**Table 14 – Correction factors for air temperature for open air LV cable installations**

$\theta_s$ (°C)	Air temperature ( $\theta_a$ in °C)										
	10	15	20	25	30	35	40	45	50	55	60
105	1.21	1.18	1.14	1.11	1.07	1.04	1	0.96	0.92	0.88	0.83
90	1.27	1.23	1.18	1.14	1.10	1.05	1	0.95	0.89	0.84	0.78
70	1.41	1.35	1.29	1.23	1.16	1.08	1	0.91	0.82	0.71	0.58
65	1.48	1.41	1.34	1.27	1.18	1.10	1	0.89	0.78	0.63	0.45

- b) The correction factor F for temperatures other than those in the table shall be:

$$F = \sqrt{\frac{\theta_s - \theta_a}{\theta_s - 40}}$$

#### 6.4.2. Correction for deficient ventilation

Where the circulation of air is not free, the temperature of the ambient air surrounding the conductors increases and therefore the maximum current shall be reduced by the correction factors for air temperature. The correction factor selected shall vary in each case depending on the increase of air temperature suffered, but as reference it may be approximated to an increase of 15 °C.


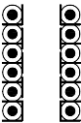

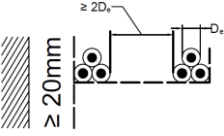
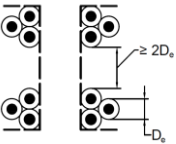
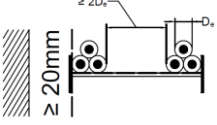
#### 6.4.3. Correction for different cable installation configurations

The following tables summarise the correction factors to be used in case of different installation configuration for groups of several single-pole or multi-pole cable circuits depending on the type of installation and the number of circuits (for a standard distance between trays of 300 mm in non-perforated trays and 225 mm between perforated trays)<sup>3</sup>, as per IEC 60364-5-52:

- a) Correction factor for groups of single-pole cables

<sup>3</sup> For the purposes of the application of this table, in case there are several conductors per phase, such group of conductors shall be considered a single circuit.

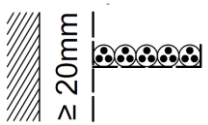
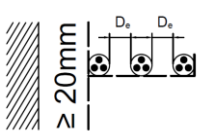

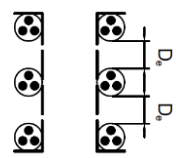
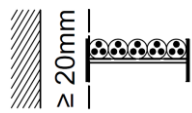
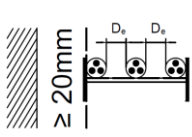
**Table 15 – Correction factor for groups of single-pole LV cables in open air installations**

Type of installation		Number of trays	Number of 3-phase circuits			To be used for:
			1	2	3	
Perforated tray, cables in contact		1	0.95	0.90	0.85	Three cables in horizontal layer
		2	0.95	0.85	0.80	
		3	-	0.85	0.80	
		1	0.95	0.85	-	
Vertical perforated tray, cables in contact		2	0.90	0.85	-	Three cables in vertical layer
Horizontal tray or support, cables in contact		1	1.00	0.95	0.95	Three cables in horizontal layer
		2	0.95	0.90	0.90	
		3	0.95	0.90	0.85	
Perforated tray		1	1.00	1.00	0.95	Three cables symmetrically staggered ("trefoil")
		2	0.95	0.95	0.90	
		3	0.95	0.90	0.85	
Vertical perforated tray		1	1.00	0.90	0.90	
		2	1.00	0.90	0.85	
Horizontal tray or support		1	1.00	1.00	1.00	
		2	0.95	0.95	0.95	
		3	0.95	0.95	0.90	



## b) Correction factor for groups of 3-pole cables

**Table 16 – Correction factors for groups of 3-pole LV cables in open air installations**

Type of installation	Number of trays	Number of 3-phase circuits					
		1	2	3	4	6	9
Perforated tray, cables in contact 	1	1.00	0.90	0.80	0.80	0.75	0.75
	2	1.00	0.85	0.80	0.75	0.75	0.70
	3	1.00	0.85	0.80	0.75	0.70	0.65
Perforated tray, spaced cables 	1	1.00	1.00	1.00	0.95	0.90	-
	2	1.00	1.00	0.95	0.90	0.85	-
	3	1.00	1.00	0.95	0.90	0.85	-
Vertical perforated tray, cables in contact 	1	1.00	0.90	0.80	0.75	0.75	0.70
	2	1.00	0.90	0.80	0.75	0.70	0.70
Vertical perforated tray, spaced cables 	1	1.00	0.90	0.90	0.90	0.85	-
	2	1.00	0.90	0.90	0.85	0.85	-
Horizontal tray or support, cables in contact 	1	1.00	0.85	0.80	0.80	0.80	0.80
	2	1.00	0.85	0.80	0.80	0.75	0.75
	3	1.00	0.85	0.80	0.75	0.75	0.70
Horizontal tray or support, spaced cables 	1	1.00	1.00	1.00	1.00	1.00	-
	2	1.00	1.00	1.00	0.95	0.95	-
	3	1.00	1.00	0.95	0.95	0.75	-

**Article 26. Minimum installation distances**

- Where a LV underground cable crosses another electrical cable, the one with lower voltage level shall be placed above those with higher voltage. The minimum distance between a LV underground cable and another electrical cable shall be 0.25 m. with MV cables and 0.10 with other LV cables. The distance between the crossing point and junctions in any of the cables that cross shall be at least 1 m. Whenever these minimum distances cannot be observed, cables shall be installed within ducts.

2. Where a LV underground cable crosses a road or way, cables shall be installed within protective pipes or ducts, covered in concrete in all their length under the road or way and placed at a minimum depth of 1 m. under ground level. Whenever possible, the crossing shall take place perpendicular to the axis of the road or way.
3. Where a LV underground cable crosses a telecommunication cable, the minimum separation between them shall be 0.20 m. The minimum distance between the crossing point and joints in any of the cables shall be 1 m. Where these minimum distances cannot be observed, the most recently installed cable shall be installed in a protective duct.
4. Where a LV underground cable crosses water, fuel or gas pipes the minimum distance between them shall be 0.20 m. The minimum distance between the crossing point and joints in the cable or the pipes shall be 1 m. Whenever possible the electricity cable shall be placed above water pipes. Where these minimum distances cannot be observed, the most recently installed cable or pipe shall be installed in a protective duct.
5. Whenever possible, electric cables shall be installed above sewerage installations. It shall not be possible to install electric cables within sewage installations.
6. Where a LV underground cable crosses a fuel tank, the cable shall be installed in a protective duct for at least 2 m. before and 2 m. after the tank and at a distance of at least 1 m.
7. LV underground cables can be installed parallel to other LV or MV cables subject keeping a distance of at least 0.10 m. with LV cables and at least 0.25 m. with MV cables. Where these minimum distances cannot be observed, the most recently installed cable shall be installed in a protective duct. In case all LV cables in parallel belong to the same owner, they can be installed at distances lower than the minimum ones above presented and even in contact.
8. The minimum distance between a LV underground cable and a telecommunications cable shall be 0.20 m. Where this minimum distance cannot be observed, the most recently installed cable shall be installed in a protective duct.
9. The minimum distance between a LV underground cable and a water, fuel or gas pipe shall be 0.20 m. In case of high pressure gas pipes, the minimum distance shall be at least 0.40 m. The minimum distance between the joints of the underground cable and those of the pipe shall be at least 1 m. Where these minimum distances cannot be observed, the most recently installed cable or pipe shall be installed in a protective duct.

## **Section 4. Standards for LV switchgear and controlgear**

### **Article 27. Requirements for LV switchgear and controlgear**

1. Switching devices and control devices installed in the LV network in outdoor areas and public areas shall comply with the requirements of IEC 61439.
2. Switching devices shall be installed as close as possible to support structures and as close as possible to the connection point of customer supplies as possible.
3. Switching devices shall be at least of class IP 65 when installed in outdoor Electrical Installations (outdoor areas and public areas).
4. LV switchgear and controlgear shall be coordinated with the MV switchgear and controlgear to grant adequate protection system coordination (trip current and trip times).

## **CHAPTER IV. STANDARDS FOR LV ELECTRICAL INSTALLATIONS (IN-HOUSE AREAS)**

### **Section 1. General Specifications**

#### **Article 28. Selection of electrical equipment**

Every item of electrical equipment selected shall have suitable characteristics appropriate to the values and conditions on which the design of the Electrical Installation is based and shall, in particular, fulfil the following requirements:

1. Electrical equipment shall be suitable with respect to the maximum steady voltage (root mean square value for alternative current systems) likely to be applied, as well as overvoltages likely to occur.
2. All electrical equipment shall be selected with respect to the maximum steady current which it has to carry in normal service, and with respect to the current likely to be carried in abnormal conditions and the period during which it may be expected to flow.
3. If frequency has an influence on the characteristic of electrical equipment, the rated frequency of the equipment shall correspond to the frequency likely to occur in the circuit.
4. All electrical equipment, which is selected on the basis of its power characteristic, shall be suitable for the duty demanded of the equipment, taking into account the load factor and the normal service conditions.
5. All electrical equipment shall be selected so as to withstand safely the stresses and the environmental conditions characteristic of its location and to which it may be exposed. If, however, an item of equipment does not have by design the properties corresponding to its location, it may be used on condition that adequate additional protection is provided as part of the completed Electrical Installation.
6. All electrical equipment shall be selected so that it will not cause harmful effects on other equipment, or impair the supply during normal service including switching operations. In this context, the factors which can have an influence include, e.g.:
  - 6.1. Power factor;
  - 6.2. Inrush current;
  - 6.3. Asymmetrical load; and
  - 6.4. Harmonics.

#### **Article 29. Erection and initial verification of Electrical Installations**

1. For the erection of the Electrical Installation, good workmanship by suitably electricians licensed by the URA and the use of proper materials shall be provided for.
2. The characteristics of the electrical equipment, as determined in accordance with Article 28 shall not be impaired in the process of erection.
3. Conductors shall be identified in accordance with IEC 60445 or any standard that replaces it

4. Connection between conductors and other electrical equipment shall be made in such a way that safe and reliable contact is ensured by the means of a mechanical fastener such that the deration of current carrying capacity is more than 1%
5. All electrical equipment shall be installed in such a manner that the design cooling conditions are not impaired.
6. All electrical equipment likely to cause high temperature or electric arcs shall be placed or guarded so as to eliminate the risk of ignition of flammable materials. Where the temperature of any exposed parts of electrical equipment is likely to cause injury to persons, those parts shall be so located or guarded as to prevent accidental contact therewith.
7. Electrical installations shall be tested and inspected before being placed in service and after important modification to verify proper execution of the work in accordance with the applicable standards.

## **Section 2. Selection and Erection of Electrical Equipment**

### **Article 30. Common rules**

1. This section deals with the selection of equipment and its erection. It shall provide compliance with the measures of protection for safety, the requirements for proper functioning for intended use of the installation, and the requirements appropriate to the external influences foreseen. Every item of equipment shall be selected and erected so as to allow compliance with the rules stated in the following clauses of this section and the relevant rules in other sections of this document.
2. Equipment shall be selected for the design current which it has to carry in normal steady operation.
3. Equipment shall also be capable of carrying the currents likely to flow in abnormal conditions for such periods of time as are determinate by the characteristic of the protective devices.
4. If frequency has an influence on the characteristics of equipment, the rated frequency of the equipment shall correspond to the frequency of the current in the circuit concerned.
5. Equipment selected for its power characteristics shall be suitable for normal operational conditions taking account of the load factor
6. Unless other suitable precautions are taken during erection, all equipment shall be selected so that it will not cause harmful effects on other equipment nor impair the supply during normal service, including switching operations.
7. Electrical equipment shall be selected and erected in accordance with the requirements of table 51A of IEC 60364-5-51 which indicates the characteristics of equipment necessary according to the external influences to which the equipment may be subjected.
8. Equipment characteristic shall be determined either by a degree of protection or by conformity of tests.
9. If the equipment does not, by its construction, have the characteristic relevant to the external influences of its location, it may nevertheless be used on condition that it is provided with appropriate additional protection in the erection of the installation, such protection shall not adversely affect the operation of the equipment thus protected.

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10. When different external influences occur simultaneously, they may have independent or mutual effect and the degree of protection shall be provided accordingly.
  11. All equipment, including wiring, shall be arranged so as to facilitate its operation, inspection and maintenance and access to its connections. Such facilities shall not be significantly impaired by mounting equipment in enclosure or compartments.
  12. Labels or other suitable means of identification shall be provided to indicate the purpose of switchgear and controlgear.
  13. Where the functioning of switchgear and controlgear cannot be observed by the operator and where this might cause a danger, a suitable indicator, complying where applicable with IEC 60073 and IEC 60447, shall be fixed in a position visible to the operator.
  14. Wiring systems shall be arranged or marked so that they can be identified for inspection, testing, repairs or alteration of the installation.
  15. The identification of separate neutral and proactive conductors shall comply with IEC 60445 or the standard that replaces it.
  16. PEN conductors, when insulated, shall be marked by one of the following methods:
    - 16.1. Green or green with yellow stripes throughout their length with, in addition, light blue marking at the terminations.
  17. The protective devices shall be arranged and identified so that circuits protected may be easily recognized.
  18. Where appropriate diagrams, charts or tables in accordance with IEC 81346-1 shall be provided indicating in particular:
    - 18.1. The type and composition of circuits (points of utilization served, number and size of conductors, type of wiring);
    - 18.2. The characteristics necessary for the identification of the devices performing the functions of protection, insulation and switching and their location.
  19. Equipment shall be selected and erected so as to avoid any harmful influence between the Electrical Installation and any non-electrical installation.
  20. Equipment not provided with a backplate shall not be mounted on a building surface unless the following required are satisfied:
    - 20.1. A voltage transfer to the building surface is prevented; and
    - 20.2. Fire segregation is provided between the equipment and a combustible building surface;
  21. If the building surface is non-metallic and non-combustible, no additional Measures are required. If not, these requirements may be satisfied by one of the following Measures:
    - 21.1. If the building surface is metallic, it shall be bonded to the protective conductor (PE) or to the equipotential bonding conductor of the installation, in accordance with IEC 60364-4-41 and IEC 60364-5-54.
    - 21.2. If the building surface is combustible, the equipment shall be separated from it by a suitable intermediate layer of insulating material having a flammability rating of FH1 according to IEC 60707.

22. Where equipment carrying currents of different types or at different voltages is grouped on a common assembly (such as a switchboard, a cubicle or a control desk or box), 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.
23. The immunity levels of equipment shall take into account the electromagnetic influences that can occur connected and erected as for normal use, and also take into account the intended level of continuity of service necessary for the application.
24. Equipment shall be chosen with sufficiently low emission levels so that it cannot cause electromagnetic interference by electrical conduction or propagation on the air with other electrical equipment inside or outside the building. If necessary, means of mitigation shall be installed to minimize the emission.

### **Article 31. Wiring systems**

#### **1. Electrical wiring**

- 1.1. Electrical wiring should be done by a URA approved and licensed electrician.
- 1.2. The conductor for electrical wiring shall be made of only copper.
- 1.3. Wiring colour code:
  - 1.3.1. In single phase wiring, the phase wire must be brown, neutral must be blue, and the earth must be green with yellow stripes.
  - 1.3.2. In three phase wiring, phase 1 must be black, phase 2 must be brown, phase 3 must be grey, neutral must be blue, and the earth must be green with yellow stripes.
  - 1.3.3. In any case, for earth wire anything other than green with yellow stripes and for neutral anything other than blue must not be used.
  - 1.3.4. As a temporary measure, for as long as the URA authorizes it, at sites where three phase wiring is required, and the prescribed colour of wire is not available, the end of each wire should be sleeved with the respective phase colour.
- 1.4. In three-phase wiring the load should be balanced among the three phases.
- 1.5. Phase wires shall be dimensioned to withstand in normal operation the aggregated current of the loads there connected. The licensed engineer or electrician (whereas applicable) shall certify dimensions of the cables.
- 1.6. The typical tripping current for earth leakage circuit breaker in households or residential buildings shall be 30 milli Amps. Nevertheless, it shall be possible to set the tripping point to different current levels where deemed necessary. The circuit breaker shall be 240 V rated voltage and 30-63 Amps rated current, 2 pole current operated ELCB. In case of three phase circuits, for a tripping current of 30 milli Amps, the circuit breaker shall be 30-63 A rated current, 380-400 rated voltage and 4 pole current operated. The rated current should not exceed the prescribed level and the tripping current must not exceed 30 milli Amps. ELCB with tripping currents less than 30mA can be accepted where it is deemed necessary. Exception to this rule are ELCB of residual current devices installed in central alternative current systems of buildings which may have trigger current higher than 30 milli Amps but in any case not exceeding 100 milli Amps.
- 1.7. For a light circuit, if the wire size is 1.5 mm<sup>2</sup> a single circuit must not exceed a total of 500W.

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- 1.8. For a light circuit, if the wire size is 2.5 mm<sup>2</sup> a single circuit must not exceed a total of 1000W.
  - 1.9. For a radial power circuit, if the wire size is 2.5 mm<sup>2</sup>, a single circuit shall not have more than 6 socket outlets while observing the following rules
    - 1.9.1. The nominal current of the circuit shall not exceed 80% of the breaker capacity
    - 1.9.2. The area which the circuit caters is limited to 20m<sup>2</sup> and the circuit shall be within the boundary of the space which it is being served
    - 1.9.3. Appliances such as Air-Conditioning, Instant Heaters, Electric Oven, Electric Stove and other high-power appliances shall be connected to their own dedicated circuit with a circuit breaker of applicable capacity.
    - 1.9.4. Appliances with power rating exceeding 1500 W shall be connected to their own dedicated circuit
  - 1.10. For a ring power circuit, if the wire size is 2.5 mm<sup>2</sup>, a single circuit shall not have more than 10 socket outlets while observing the following rules
    - 1.10.1. The nominal current of the circuit shall not exceed 80% of the breaker capacity
    - 1.10.2. The area which the circuit caters is limited to 30m<sup>2</sup> and the circuit shall be within the boundary of the space which it is being served
    - 1.10.3. Appliances such as Air-Conditioning, Instant Heaters, Electric Oven, Electric Stove and other high-power appliances shall be connected to their own dedicated circuit with a circuit breaker of applicable capacity.
    - 1.10.4. Appliances with power rating exceeding 2000 W shall be connected to their own dedicated circuit
  - 1.11. Not more than one phase must be used in a single box
  - 1.12. Wiring must be done in a conduit or trunking.
  - 1.13. Machineries installed in commercial and industrial electrical installations must be connected by using appropriate cable size and through starter or main switch. Such starter switch must be installed close to the machinery in an easy to operate manner.
  - 1.14. Water prone areas should have water proof switches and socket outlets. if normal switches & sockets are used, it must be mounted where water will not reach it.
  - 1.15. For loads not exceeding 13 Amps, the socket shall be of Type G BS-1363.
  - 1.16. For loads up to 15 Amps, the socket shall conform to BS 546
  - 1.17. If a socket other than what is mentioned in 1.15 and 1.16 is being used, it shall conform to IEC 60884
  - 1.18. Insulation resistance of an installation (phase-neutral, phase-earth and neutral-earth) should have minimum of 1 mega ohm.



- 1.19. In case a resident needs to connect a backup/emergency generator apart from the existing service provider's supply, the necessary permit should be obtained from URA and a change-over switch must be introduced. The change-over switch must be able to disconnect the phase/live conductors and as well as the neutral, and must present a rating adequate to the required load.
- 1.20. All new electrical installations shall be tested and approved by either licensed engineers or electricians (according to the case) for such purposes, before being energized and will be accountable if any fault arises from the distribution board wiring.

## 2. Distribution Board

- 2.1. The DB shall be protected by a cover with degree of protection of at least IP 30 for indoor case and IP 65 for outdoor case.
- 2.2. DB shall be fixed at a height of 1.8 m. In the case of DBs with multiple rows, the highest point shall not be less than 1.8 m
- 2.3. The Distribution Board shall include at least the following switching and control devices:
  - 2.3.1. A Power Control Switch that cuts the power supply in case the power withdrawn overshoots the contracted capacity.
  - 2.3.2. A main switch circuit breaker, omnipolar, with capability for manual operation and equipped with protection against overloading and short-circuits. This circuit breaker shall be independent from the Power Control Switch.
  - 2.3.3. A residual current device, which shall protect the Electrical Installation against indirect contacts in any of the circuits by automatically disconnecting it from the power supply.
  - 2.3.4. Individual omnipolar circuit breaker to protect each of the circuits that form the Electrical Installation in-house.
  - 2.3.5. Any specific control device that may be required for the application of the selected electricity tariff to the Electrical Installation.
- 2.4. Optionally, the DB may also include a device for protection against overvoltage.
- 2.5. Every socket circuit must be wired to the DB with a phase wire along with the earth and neutral wire. At the DB, the circuit breaker must be appropriately sized for the socket circuit and it should not be higher than what is required.

In a building the earth wire connected to ground should be appropriately thick to allow wheeling the foreseen short-circuit current in the electrical installation, including lightning discharges. The main earth wire should originate from the distribution board (DB) or the main switch via the assigned site. The earth wire should be connected solidly connected to the earth rod. Inspection chamber shall be provided for testing of main earthing.

## 3. Selection and erection in relation to external influences

- 3.1. The wiring system shall be selected and erected so as to be suitable for the highest local ambient temperature.
- 3.2. Wiring system components including cables and wiring accessories shall be installed or handled only at temperature within the limits stated in the relevant product specification or as given by the manufacturer.

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- 3.3. In order to avoid the effects of heat from external sources one of the following methods or an equally method shall be used to protect wiring systems:
    - 3.3.1. Shielding;
    - 3.3.2. Placing sufficiently far from the sources of heat;
    - 3.3.3. Selecting a system with due regard for the additional temperature rise which may occur; or
    - 3.3.4. Local reinforcement or substitution of insulating material.
  - 3.4. The wiring system shall be selected and erected so that no damage is caused by ingress of water. The completed wiring system shall comply with the IP degree of protection relevant to the particular location.
  - 3.5. Where water may collect or condensation may form in wiring system, provision shall be made for its escape.
  - 3.6. Where wiring system may be subjected to waves, protection against mechanical damage shall be afforded.
  - 3.7. Wiring system shall be selected and erected so as to minimize the danger arising from the ingress of solid foreign bodies. The completed wiring system shall comply with the IP degree of protection relevant to the particular location.
  - 3.8. In a location where dust in significant quantity is present, additional precaution shall be taken to prevent the accumulation of dust or other substances in quantities which could adversely affect the heat dissipation from the wiring system.
  - 3.9. Where the presence of corrosive or pollution substances, including water, is likely to give rise to corrosion or deterioration, parts of the wiring system likely to be affected shall be suitably protected or manufactured from a material resistant to such substances.
  - 3.10. Dissimilar metals liable to initiate electrolytic action shall not be placed in contact with each other, unless special arrangements are made to avoid the consequences of such contacts.
  - 3.11. Material liable to cause mutual or individual deterioration or hazardous degradation shall not be placed in contact with each other.
  - 3.12. The wiring system shall be selected and erected so as to minimize the damage arising from mechanical stress, e.g. by impact, penetration or compression.
  - 3.13. In installations fixed to a structure or equipment, fixation shall be afforded by:
    - 3.13.1. The mechanical characteristics of the wiring system; or
    - 3.13.2. The location selected; or
    - 3.13.3. The provision of additional local or general mechanical protection; or
    - 3.13.4. By any combination of the above.
  - 3.14. The wiring system supported by or fixed to structure of equipment subject to vibration of medium severity or high severity shall be suitable for such conditions, particularly where cables and cable connection are concerned.

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- 3.15. The wiring system shall be selected and erected so as to prevent during installation, use or maintenance, damage to sheath and insulation of cables and conductor and their terminations.
  - 3.16. When buried in the structure, conduits or cable ducting system shall be completely erected for each circuit before any insulated conductor or cable is drawn in.
  - 3.17. The radius of every bend in a wiring system shall comply with the minimum bending radius recommended by the cable or wire manufacturer.
  - 3.18. Where the conductors and cables are not supported continuously by their supports or due to the method of the installation, they shall be supported by suitable means at appropriate intervals in such a manner that the conductors and cables do not suffer damage by their own weight.
  - 3.19. Where a permanent tensile stress is applied to the wiring system (e.g. by its own weight in vertical runs) a suitable type of cable or conductor with appropriate cross-sectional areas and method of mounting shall be selected, in such a manner that the conductors and cables do not suffer damage by their own weight.
  - 3.20. Wiring system intended for the drawing in or out of conductors or cables shall have adequate means of access to allow this operation.
  - 3.21. Wiring system buried in floors shall be sufficiently protected to prevent damage caused by the intended use of the floor.
  - 3.22. Wiring system which are rigidly fixed and buried in the walls shall be run horizontally or vertically or parallel to the room edges.
  - 3.23. Wiring system shall be installed so that excessive tensile stress to the conductors and connections is avoided.
  - 3.24. Flexible wiring system shall be installed so that excessive tensile stress to the conductors and connection is avoided.
  - 3.25. Where the conditions experienced or expected constitute a hazard the wiring system shall be selected accordingly or special protective measures shall be adopted.
  - 3.26. Where significant solar radiation is experienced or expected, a wiring system suitable for the conditions shall be selected and erected or adequate shielding shall be provided.
  - 3.27. The wiring system shall be selected and erected with due regard to the seismic hazards of the location of the installation.
  - 3.28. Where the seismic hazards experienced are low severity or higher, particular attention shall be paid to the following:
    - 3.28.1. The fixing of wiring system to the building structure; and
    - 3.28.2. The connections between the fixed wiring and all items of essential equipment, e.g. safety services, shall be selected for their flexible quality.
  - 3.29. Where the risk due to structural movement exists, the cable support and protection system employed shall be capable of permitting relative movement so that conductors and cables are not subjects to excessive mechanical stress.
  - 3.30. For flexible or unstable structures, flexible wiring system shall be used.

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#### 4. Electrical connections

- 4.1. Connections between conductors and between conductors and other equipment shall provide durable electrical continuity and adequate mechanical strength and protection.
- 4.2. The selection of the means of connection shall take account as appropriate of:
  - 4.2.1. the material of the conductor and its insulation;
  - 4.2.2. the number and shape of the wires forming the conductor;
  - 4.2.3. the cross-sectional area of the conductor; and
  - 4.2.4. the number of conductors to be connected together.
- 4.3. All connections shall be accessible for inspection, testing and maintenance, except for the following:
  - 4.3.1. Joints in buried cables;
  - 4.3.2. Compound-filled or encapsulated joints;
  - 4.3.3. Connections between a cold tail and the heating element as in ceiling heating, floor heating and trace heating system.
- 4.4. Where necessary, precautions shall be taken so that the temperature attained by connections in normal service shall not impair the effectiveness of the insulation of conductors connected to them or supporting them.

#### 5. Selection and erection to minimize the spread of fire

- 5.1. The wiring system shall be installed so that the general building structural performance and fire safety are not reduced.
- 5.2. Where a wiring system passes through elements of building construction such as floors, walls, roofs, ceilings, partitions or cavity barriers, the opening remaining after passage of the wiring system shall be sealed according to the degree of fire resistance (if any) prescribed for the respective element of building construction before penetration.
- 5.3. Wiring systems such as conduits, cable ducting, cable trunking, busbars or busbar trunking system which penetrate elements of building construction having specified fire resistance shall be internally selected to the degree of fire resistance of the respective element before penetration as well as being externally sealed as required by Point 5.2 of this Article.
- 5.4. No wiring system shall penetrate an element of building construction which is intended to be load bearing unless the integrity of the load bearing element can be assured after such penetration.
- 5.5. Sealing arrangements shall resist external influences to the same degree as the wiring system with which they are used and in addition they shall all of the following requirements:
  - 5.5.1. They shall be resistant to the products of combustion to the same extent as the elements of building construction which have been penetrated;
  - 5.5.2. They shall provide the same degree of protection from water penetration as that required for the building construction element in which they have been installed;

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- 5.5.3. The seal and the wiring system shall be protected from dripping water which may travel along the wiring system or which may otherwise collect around the seal unless the materials used in the seal are all resistant to moisture when finally assembled for use.
  - 5.6. During erection of a wiring system temporary arrangements may be used if required.
  - 5.7. During alteration work, sealing should be reinstated as quickly as possible.
  - 5.8. The sealing arrangements shall be inspected to verify that they conform to the erection instruction associated with the Integrated Circuit Type Test for the product concerned.
  - 5.9. Band I and Band II voltage circuits, as per IEC 60449, shall not be contained in the same wiring system unless every cable is insulated for the highest voltage present or one of the following methods is adopted:
    - 5.9.1. Each conductor of a multi-core cable is insulated for the highest voltage present in the cable; or
    - 5.9.2. The cables are insulated for their system voltage and installed in separate compartment of a cable ducting or cable trunking system; or
    - 5.9.3. A separate conduit system is employed.
  - 5.10. Wiring systems shall not be installed in the vicinity of service which produce heat, smoke or fumes likely to be detrimental to the wiring, unless it is protected from harmful effects by shielding arranged so as not to affect the dissipation of heat from the wiring.
  - 5.11. Where a wiring system is routed below services liable to cause condensation (such as water, steam or gas services), precautions shall be taken to protect the wiring system from deleterious effects).
  - 5.12. Where electrical services are to be installed in proximity to non-electrical services they shall be so arranged that any foreseeable operation carried out on the other services will not cause damage to the electrical services or the converse.
  6. Selection and erection in relation to maintainability, including cleaning
    - 6.1. The knowledge and experience of the person or persons likely to carry out the maintenance shall be taken into account in the selection and erection of the wiring system.
    - 6.2. Where it is necessary to remove any protective measure in order to carry out maintenance, provision shall be made so that the protective measure can be reinstated without reduction of the degree of protection originally intended.
    - 6.3. Provision shall be made for safe and adequate access to all parts of the wiring system which may require maintenance.
  7. Use of Flexible Cables for fixed wiring
    - 7.1. Construction
      - 7.1.1. Flexible conductors shall consist of plain or metal coated annealed copper
      - 7.1.2. The strands in each conductor shall have the same nominal diameter

- 7.1.3. The cross-sectional area of the cables shall not be smaller than 4 mm<sup>2</sup> and not larger than 10 mm<sup>2</sup>
- 7.1.4. Flexible cables shall only be used for internal wiring.
- 7.1.5. Flexible cables used for fixed wiring shall be of heavy-duty type as specified in BS 7540
- 7.1.6. The current carrying capacity of cable shall be de-rated by a factor of 0.85
- 7.1.7. Only cables with the model code suffix '-K' shall be used for fixed wiring

## 7.2. Rules for Use

- 7.2.1. Flexible cables shall not be used as fixed wiring unless they are contained in an enclosure affording mechanical protection
- 7.2.2. The exposed length of the flexible cable used as final connections to fixed equipment shall be short as practically possible and should be connection direct and not via an intermediate node.
- 7.2.3. Flexible cables shall be installed only in surface mounted trunking or embedded conduit.
- 7.2.4. Flexible cables shall not be installed in plaster
- 7.2.5. Flexible cable shall not be subject to excessive tension, crushing, abrasion, torsion and kinking. Particularly at the inlet of the appliance and at the point of connection to the fixed wiring. They shall not be damaged by any strain relief or clamping device.
- 7.2.6. Flexible cable shall not be placed under carpets or other floor coverings, where there is:
  - 7.2.6.1. Any risk of thermal insulating effects, leading to excessive temperature rise or;
  - 7.2.6.2. Any risk of damage due to furniture or equipment resting on them or traffic passing over them
- 7.2.7. Non-sheathed cables shall not be used for connection to any Class II appliance (IEC 61140), or for any extension lead or for the replacement of any sheathed cable type
- 7.2.8. When flexible cables are required for use outdoors, whether for intermittent, temporary or permanent usage, their suitability for such use shall be determined in accordance with EN 50565-2. Flexible thermoplastic cables are unsuitable for permanent use outdoors

## 7.3. Termination

- 7.3.1. Flexible cables shall be terminated mechanically on both ends by the means of a suitable terminal connector
- 7.3.2. Equipment used for the purpose of crimping the terminal connector shall have a self-releasing mechanism such that the action of crimping does not damage the strands of the flexible cable and does not reduce the cross-sectional area beyond a factor of 0.85

**Article 32. Insulation, switching and control devices**

1. Every Electrical Installation for residential use at LV shall be equipped with at least:
  - 1.1. A Power Control Switch (PCS):
    - 1.1.1. Capable and configured to disconnect the Electrical Installation main supply in case the power demanded is higher than the power contracted (and for which the PCS is configured).
    - 1.1.2. The PCS shall be installed at the distribution board serving the Electrical Installation.
  - 1.2. A main switch circuit breaker shall be selected to be able to cut the aggregated current of the group of Electrical Installation supplied from it in case of short-circuit, and in any case at least 4.5 kA.
  - 1.3. A residual current protective device:
    - 1.3.1. Residual current devices in direct current system shall be specially designed for detection of direct current residual currents, and to break circuit currents under normal conditions and fault conditions.
    - 1.3.2. Residual current protective devices shall ensure the disconnection of all phase and neutral conductors in the circuit protected.
    - 1.3.3. No protective conductor shall pass through the magnetic circuit of a residual current protective device.
    - 1.3.4. Residual current protective devices shall be so selected, and the electrical circuits so subdivided, that any earth-leakage current which may be expected to occur during normal operation of the connected lead(s) will be unlikely to cause unnecessary tripping of the device.
    - 1.3.5. The use of a residual current protective device associated with circuit not having a protective conductor, even if the rated operating residual current does not exceed 30 mA, shall not be considered as a measure sufficient for protection against indirect contact.
    - 1.3.6. The use of residual current protective devices with an auxiliary source not operating automatically in the case of failure of the auxiliary source is permitted only if one of two following conditions is fulfilled:
      - 1.3.6.1. Protection against indirect contact is ensured even in the case of failure of the auxiliary supply;
      - 1.3.6.2. The devices are installed in installation operated, tested and inspected by instructed person or skilled persons.

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**Article 33. Earthing arrangements and protective conductors**

1. The performance of the earthing arrangements shall be adapted to the safety and functional requirements of the Electrical Installation.
2. The selection and erection of the equipment of the earthing arrangements shall be such that:
  - 2.1. The value of earthing resistance is in accordance with protective and functional requirements of the installation and expected to be continuously effective;
  - 2.2. Earth-fault currents and earth-leakage currents can be carried without danger, particularly from thermal, thermo-mechanical and electro-mechanical stresses; and
  - 2.3. It is adequately robust or against or has additional mechanical protection appropriate to the assessed condition of external influences.
3. Precautions shall be taken against the risk of damage to other metallic parts through electrolysis.
4. Earth electrodes for earthing Electrical Installations
  - 4.1. The following types of earth electrodes may be used:
    - 4.1.1. Earth rods or pipes;
    - 4.1.2. Earth tapes or wires;
    - 4.1.3. Earth plates;
    - 4.1.4. Earth electrodes embedded in foundation;
    - 4.1.5. Metallic reinforcement of concrete
    - 4.1.6. Metallic water-pipe system
    - 4.1.7. Other suitable underground structures
  - 4.2. The type and embedded depth of earth electrodes shall be such that soil drying and freezing will not increase the earth resistance of the earth electrodes above the required value.
  - 4.3. The materials used and the construction of the earth electrodes shall be such as to withstand mechanical damage due to corrosion.
  - 4.4. The design of the earthing arrangements shall take account of possible increase in earth resistance of earth electrodes due to corrosion.
  - 4.5. Metallic water-pipe system may be used as earth electrodes provided that the consent of the distributor of the water is obtained and that suitable arrangements exist for the user of the Electrical Installation to be warned of any proposed changes in the water-pipe system.
  - 4.6. Metallic pipe system of service other than that mentioned in Point 4.5 as this concerns only the water service, (e.g. for flammable liquids or gases, heating system, etc.) shall not be used as earth electrodes for protective purposes.
  - 4.7. Lead sheaths and other metallic covering of cables not liable to deterioration through excessive corrosion may be used as earth electrodes provided the consent of the owner of the cables is obtained and suitable arrangements exist for the user of the Electrical Installation to be warned of any proposed changes to the cable that may affect its suitability as an earth electrode.



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5. The connection of an earthing system to an earth electrode shall be soundly made and electrically satisfactory. Where a clamp is used, it shall not damage the electrode (e.g. a pipe) of the earthing conductor.
  6. In every installation, a main earthing terminal or bar shall be provided and the following conductors shall be connected to it:
    - 6.1. Earthing conductors;
    - 6.2. Protective conductors;
    - 6.3. Main equipotential bonding conductors; and
    - 6.4. Functional earthing conductors, if required.
  7. Means shall be provided in an accessible position for disconnecting the earthing conductor. Such Means may conveniently be combined with the main earthing terminal or bar, to permit measurement of the resistance of the earthing arrangements. This joint shall be disconnectable only by means of a tool, shall be mechanically strong, and ensure the maintenance of electrical continuity.
  8. The cross-sectional area of every protective conductor which does not form part of the supply or cable enclosure shall be, in any case, not less than:
    - 8.1. 2.5 mm<sup>2</sup> if mechanical protection is provided; or
    - 8.2. 4 mm<sup>2</sup> if mechanical protection is not provided.
  9. Protective conductors may comprise:
    - 9.1. Conductors in multi-core cables;
    - 9.2. Insulated or bare conductors in a common enclosure with live conductors;
    - 9.3. Fixed bare or insulated conductors;
    - 9.4. Metal covering, for example, the sheaths, screens and armouring of certain cables;
    - 9.5. Metal conduits or other metal enclosures for conductors; and
    - 9.6. Certain extraneous conductive parts.
  10. Protective conductors shall be suitably protected against mechanical and chemical deterioration and electrodynamic forces.
  11. Joints of protective conductors shall be accessible for inspection and testing except in compound-filled or encapsulated joints.
  12. No switching devices shall be inserted in the protective conductors, but joints can be disconnected for test purposes by use of a tool.
  13. Where monitoring of earth-continuity is used, the operating coils shall not be inserted in protective conductors.
  14. Where overcurrent protective devices are used for protection against Electric Shock, the incorporation of the protective conductor in the same wiring system as the live conductors or in their immediate proximity is strongly recommended.
  15. An auxiliary earth electrode shall be provided electrically independent of all other earthed metal, for example, constructional metalwork, pipes, or metal-sheathed cables. This requirement is considered to be fulfilled if the auxiliary earth electrode is installed at specified distance from all other earthed metal.

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16. The earthing conductor leading to the auxiliary earth electrode shall be insulated to avoid contact with the protective conductor or any of the parts connected thereto or extraneous conductive parts which are, or may be, in contact with them.
  17. The protective conductor shall be connected only to the exposed conductive parts of those items of electrical equipment whose supply will be interrupted in the event of the protective device operating under fault conditions.
  18. Earthing arrangements for functional purposes shall be provided to ensure correct operation of equipment or to permit reliable and proper functioning of the installation.
  19. In TN system, for cables in fixed installation having a cross-sectional area not less than 10 mm<sup>2</sup> for copper, a single conductor may serve both as protective conductor and neutral conductor, provided that the part of the installation concerned is not protected by a residual current-operated device.
  20. The minimum cross-sectional area of a PEN conductor may be 4 mm<sup>2</sup>, provided that the cable is of a concentric type conforming to IEC standard and that duplicate continuity connection exist at all joints termination in the run of the concentric conductors.
  21. The PEN conductors shall be insulated for the highest voltage to which it may be subject to avoid stray currents.
  22. If from any point of the installation the neutral and protective function are provided by separate conductors, it is inadmissible to connect these conductors to each other from that point. At the point of separation, separate terminal or bars shall be provided for the protective and neutral conductors. The PEN conductor shall be connected to the terminal or bar intended for the protective conductor.
  23. Main equipotential bonding conductors shall have cross-sectional areas not less than half the cross-sectional area of the largest protective conductor of the installation, subject to a minimum of 6 mm<sup>2</sup>. However, the cross-sectional area need not exceed 25 mm<sup>2</sup> if the bonding conductor is of copper or a cross-sectional area affording equivalent current-carrying capacity in other metals.
  24. A supplementary equipotential bonding conductor connecting two exposed conductive parts may have a cross-sectional area not less than of the smaller protective conductor connected to the exposed conductive parts.
  25. A supplementary equipotential bonding conductor connecting exposed conductive parts to extraneous conductive parts may have a cross-sectional area not less than the cross sectional area of the corresponding protective conductor.
  26. Supplementary equipotential bonding may be extraneous conductive parts of a permanent nature, such as structural metalwork, or by supplementary conductors, or by a combination of these.
  27. Where water pipes of building are used for earthing or as protective conductors, the water meter shall be bonded across and the bonding conductor shall be of appropriate cross-sectional area according to its use as a protective conductor, equipotential bonding conductor or functional earthing conductor.

## CHAPTER V. STANDARDS FOR MV ELECTRICAL INSTALLATIONS (OUTDOOR AND PUBLIC AREAS AND PRIVATE AREAS)

### Section 1. Standards for MV Underground Cables

#### Article 34. Standard voltage levels

1. Any voltage level higher than 1 kV and equal or lower than 35 kV (phase to phase) shall be considered MV. Out of all the possible voltage levels, the preferred nominal system voltage levels for underground lines in outdoor areas and public areas in the Republic of Maldives is 11 kV (phase to phase).
2. Equipment in MV Electrical Installations shall be able to withstand the following maximum voltage without deterioration as per IEC 60183:

**Table 17 – Minimum voltage withstand levels for equipment in MV underground Electrical Installations**

Rated voltage of cables and accessories ( $U_0$ )	Nominal system voltage (U)	Highest voltage for equipment ( $U_m$ )
kV	kV	kV
3	3	3.6
6	6	7.2
11	11	12
15	15	17.5
20	20	24
30	30	36

3. Electrical Installations in private areas may present any voltage level as long as the adequate voltage level conversion systems are installed where those installations are connected to the Distribution Network.

#### Article 35. Conductors

1. All MV underground cables shall use copper conductors of cross section no lower than 10 mm<sup>2</sup>.
2. In general, cables shall be equipped with the same insulation, screens and sheaths as the network to which they are connected.
3. Cables shall be adequately screened and protected against corrosive agents present in the terrain surrounding them.
4. Cables shall support the mechanic efforts required for their deployment and trenching.

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**Article 36. Installation of underground cables**

1. Underground cables shall be installed:
  - 1.1 In public terrain where possible;
  - 1.2 In a path as straight as possible, in parallel with the main surrounding buildings' facades where possible;
  - 1.3 With clear indications, at each accessible point, of the hazardous nature of the cable; and
  - 1.4 Observing the minimum cable bend radius as set by the manufacturer.
2. Underground cables can be either:
  - 2.1 Directly buried cables; or
  - 2.2 Cable in duct.
3. Directly buried cables:
  - 3.1 Shall be buried so that the upper border of the cable is at least 0.6 m. below the surface if under a sidewalk or at least 1 m. if under a road.
  - 3.2 Lower deepness can be accepted if the cable is adequately equipped with additional mechanic protections.
  - 3.3 A layer of at least 5 cm. of dissimilar sand or material of similar characteristics shall be deposited immediately over the trench and under the cable, free of extraneous bodies.
  - 3.4 A layer of at least 10 cm. of dissimilar sand or material of similar characteristics shall be deposited immediately over the cable, free of extraneous bodies.
  - 3.5 The sides of the trench shall be stable and not present rockfall risk.
  - 3.6 In order to avoid damage due to excavations made by third parties, cables shall be mechanically protected to withstand a point impact of 20 J of energy. The mechanical protection shall cover the plan projection of the cable.
4. Cables in duct:
  - 4.1 Shall be buried so that the upper border of the duct is at least 0.6 m. below the surface if under a sidewalk or at least 0.8 m. if under a road.
  - 4.2 Ducts where the cable is installed shall be made in synthetic material, cement and derivatives or in metal subject to withstand the necessary mechanical efforts.
  - 4.3 The inner diameter of the duct shall not be less than 1.5 times the diameter of the cable or of the apparent diameter of the set of cables in case several cables are installed in the same duct.
  - 4.4 The interior of the duct shall be smooth so as to facilitate the installation and removal of the cables.
  - 4.5 No more than one circuit of cables shall be installed per duct.
  - 4.6 In case only one single-pole cable is installed in a duct, the duct shall be made in non-ferromagnetic material.

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- 4.7 The deployment of the duct shall avoid bend ratios smaller than those recommended by the manufacturer of the cable.
  - 4.8 Inspection chambers shall be installed at each end of the cable. Intermediate inspection chambers can be installed in order to avoid tensile strengths higher than those recommended by the manufacturer of the cable.
  5. Where a cable shall cross under water surfaces (such as the sea or a lake), a special project shall be required, which shall take into account all efforts suffered by the cable (load and stress due to the tides, the pressure, efforts during the deployment of the cable, etc.). The cable shall be protected against damages from external bodies such as anchors, trawls, etc. The area of transition from underwater to overwater shall be particularly protected against undesired movements of the cable.
  6. Inside buildings and in particular inside substations, cables can be installed on trays or hung or attached to the wall. In this cases, where the cable is located lower than 4 m above the ground a protective cover shall be installed, which will require a tool to be opened.
  7. All metallic support and protective structures and accessories shall be connected to the ground network of the installation. Ducts shall be connected to ground at least every 10 m. and at both ends.
  8. Cables' metallic screen shall be connected to the ground at its two terminal boxes (junction boxes).

#### **Article 37. Aerial – underground transition**

1. In connections of an underground cable to an aerial network,
  - 1.1. The rising cable shall be protected with a cover made in metal, cement and derivatives or synthetic material with adequate mechanic strength.
  - 1.2. The inner surface of the cover shall be smooth to facilitate the installation and removal of the cable without damage.
  - 1.3. The upper end of the cover shall prevent water from entering the cover.
  - 1.4. The cover shall rise at least 2.5 m. above the ground.
  - 1.5. The diameter of the cover shall be at least 1.5 times the diameter of the cable or the apparent diameter of the set of cables it protects.
  - 1.6. In case the cover protects a single single-pole cable, it shall be made in plastic or non-ferromagnetic material to avoid heating due to Eddy currents.

#### **Article 38. Plans and access to the position of cables**

1. The owner of the cables shall, once the cables are deployed, have a plan indicating the exact routing and characteristics of the cables so that it is possible to pinpoint them in the future.
2. Any construction project that may impact or be impacted by underground cables shall ask the owner of the cables for their location at least 20 Business Days in advance and the owner of the cables shall provide the required information within 5 Business Days of the receipt of the request. The owner of the cables shall have the right to be present during the excavations. For coordination purposes, the owner of the cables shall therefore inform the constructor of its interest to be present alongside the response to the information request.

### Article 39. Electrical calculations

1. Electrical calculation shall be made to obtain the electrical parameters, maximum currents, voltage drops and power losses associated to the MV underground cable under all foreseen operation modes in order to avoid overshooting the maximum temperature for the cable.
2. The maximum current admissible during steady operation shall depend on the maximum temperature the insulation of the cable is able to withstand without deteriorating its electrical, mechanical or chemical properties. Maximum temperatures for cables with dry insulation are those indicated in the following table, as per IEC 60287, or as indicated by the manufacturer:

**Table 18 – Maximum temperatures for dry insulation MV underground cables in the MV Distribution Network**

Type of dry insulation	Steady operation ( $\Theta_s$ in °C)	Short-circuit no longer than 5 seconds ( $\Theta_{sc}$ in °C)
Polyvinylchloride (PVC)*	70	160
Crosslinked Polyethylene (XLPE)	90	250
Ethylene Propylene (EPR)	90	250
Hard grade Ethylene Propylene (HEPR)	105	250

*\*Only suitable for installation not higher than 6kV*

3. Directly buried installations
  - 3.1. The maximum current in steady operation shall be determined based on the base installation: dry insulation installation up to 18/30 kV composed of three single-pole cables directly buried in all their length at 1 m. under the ground (Measured from the ground surface down to the upper side of the cable), in a soil with average thermal resistivity equal to 1.5 K.m./W., with an average soil temperature at the mentioned depth of 25 °C and ambient air temperature of 40 °C.
  - 3.2. The calculation of the maximum current shall be adapted to each particular situation to ensure that the maximum temperature generated by the calculated current is not higher than the one stipulated in Point 2 of this Article.
  - 3.3. Maximum steady operation current (A.) for the base installation with copper conductor as per IEC 60287:

**Table 19 – Maximum steady operation current for the base installation in directly buried MV underground cables**

Conductor cross section (mm <sup>2</sup> )	EPR	XLPE	HEPR
25	125	130	135
35	145	155	160
50	175	180	190
70	215	225	235
95	255	265	280
120	290	300	320
150	325	340	360
185	370	380	405
240	425	440	470

#### 4. Cables in duct

- 4.1. The maximum current in steady operation shall be determined based on the base installation: dry insulation installation up to 18/30 kV composed of three single-pole cables buried in duct in all their length at 1 m. under the ground (Measured from the ground surface down to the upper side of the cable), in a soil with average thermal resistivity equal to 1.5 K.m./W., with an average soil temperature at the mentioned depth of 25 °C and ambient air temperature of 40 °C.
- 4.2. The calculation of the maximum current shall be adapted to each particular situation to ensure that the maximum temperature generated by the calculated current is not higher than the one stipulated in Point 2 of this Article.
- 4.3. Maximum steady operation current (A.) for the base installation with copper conductor as per IEC 60287:

**Table 20 – Maximum steady operation current for the base installation in MV underground cables in ducts**

Conductor cross section (mm <sup>2</sup> )	EPR	XLPE	HEPR
25	115	120	125
35	135	145	150
50	160	170	180
70	200	205	220
95	235	245	260
120	270	280	295
150	305	315	330
185	345	355	375
240	400	415	440

## 5. Correction factors for buried cables (directly or in duct)

### 5.1. Correction for soil temperature

5.1.1. Where the average temperature of the soil is different than 25 °C, the following correction factor F shall be applied to direct buried cables depending on the maximum temperature for the conductor ( $\Theta_s$ ) as per IEC 60287:

**Table 21 – Correction factor F for soil temperature different than 25 °C for direct buried MV cables**

$\Theta_s$ (°C)	Soil temperature ( $\Theta_t$ in °C)								
	10	15	20	25	30	35	40	45	50
105	1.09	1.06	1.03	1.00	0.97	0.94	0.90	0.87	0.83
90	1.11	1.07	1.04	1.00	0.96	0.92	0.88	0.83	0.78
70	1.15	1.11	1.05	1.00	0.94	0.88	0.82	0.75	0.67
65	1.17	1.12	1.06	1.00	0.94	0.87	0.79	0.71	0.61

5.1.2. The correction factor F for temperatures other than those in the table shall be:

$$F = \sqrt{\frac{\Theta_s - \Theta_t}{\Theta_s - 25}}$$

### 5.2. Correction for soil thermal resistivity

5.2.1. Where the thermal resistivity of the soil is different than 1.5 K.m./W., the following correction factor shall be applied as per IEC 60287:



**Table 22 – Correction factor for soil thermal resistivity different than 1.5 K.m/W. For MV underground cables**

Type of installation	Conductor cross section (mm <sup>2</sup> )	Soil's thermal resistivity (K.m./W.)						
		0.8	0.9	1.0	1.5	2.0	2.5	3
Directly buried cables	25	1.25	1.20	1.16	1.00	0.89	0.81	0.75
	35	1.25	1.21	1.16	1.00	0.89	0.81	0.75
	50	1.26	1.21	1.16	1.00	0.89	0.81	0.74
	70	1.27	1.22	1.17	1.00	0.89	0.81	0.74
	95	1.28	1.22	1.18	1.00	0.89	0.80	0.74
	120	1.28	1.22	1.18	1.00	0.88	0.80	0.74
	150	1.28	1.23	1.18	1.00	0.88	0.80	0.74
	185	1.29	1.23	1.18	1.00	0.88	0.80	0.74
	240	1.29	1.23	1.18	1.00	0.88	0.80	0.73
	25	1.12	1.10	1.08	1.00	0.93	0.88	0.83
Cables in duct	35	1.13	1.11	1.09	1.00	0.93	0.88	0.83
	50	1.13	1.11	1.09	1.00	0.93	0.87	0.83
	70	1.13	1.11	1.09	1.00	0.93	0.87	0.82
	95	1.14	1.12	1.09	1.00	0.93	0.87	0.82
	120	1.14	1.12	1.10	1.00	0.93	0.87	0.82
	150	1.14	1.12	1.10	1.00	0.93	0.87	0.82
	185	1.14	1.12	1.10	1.00	0.93	0.87	0.82
	240	1.15	1.12	1.10	1.00	0.92	0.86	0.81

5.2.2. The thermal resistivity of the soil varies with the type of soil and its humidity, being higher the higher the humidity is:

**Table 23 – Reference soil resistivity levels and associated type of soil and humidity**

Soil resistivity (K.m./W.)	Type of soil and humidity
0.40	Inundated land
0.50	Very wet
0.70	Wet
0.85	A little wet
1.00	Dry
1.20	Very dry clay soil
1.50	Very dry sandy soil
2.00	Sandstone
2.50	Limestone
3.00	Granite

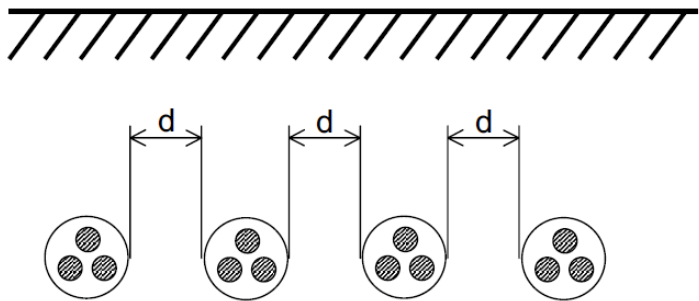
5.3. Correction for composition of the cable

- 5.3.1. Where there are more than one 3-pole cable or more than one triplet of single pole cables the following correction factors shall be applied depending on the number of those 3-pole cables or triplets and the distances between them, as per IEC 60287:

**Table 24 – Correction factors for composition of the cable in MV underground cables**

Type of installation	Distance between 3-poles or triplets (d, in m.)	Number of 3-poles or triplets in the trench or duct								
		2	3	4	5	6	7	8	9	10
Directly buried cables	In contact (d = 0)	0.76	0.65	0.58	0.53	0.50	0.47	0.45	0.43	0.42
	0.2	0.82	0.73	0.68	0.64	0.61	0.59	0.57	0.56	0.55
	0.4	0.86	0.78	0.75	0.72	0.70	0.68	0.67	0.66	0.65
	0.6	0.88	0.82	0.79	0.77	0.76	0.74	0.74	0.73	-
	0.8	0.90	0.85	0.83	0.81	0.80	0.79	-	-	-
Cables in duct	In contact (d = 0)	0.80	0.70	0.64	0.60	0.57	0.54	0.52	0.50	0.49
	0.2	0.83	0.75	0.70	0.67	0.64	0.62	0.60	0.59	0.58
	0.4	0.87	0.80	0.77	0.74	0.72	0.71	0.70	0.69	0.68
	0.6	0.89	0.83	0.81	0.79	0.78	0.77	0.76	0.75	-
	0.8	0.90	0.86	0.84	0.82	0.81	-	-	-	-

**Figure 3 – Scheme of distribution of buried MV underground cables**



5.4. Correction for depth different than 1 m.

5.4.1. Where there cables are buried at depths different than 1 m. the following correction factors shall be applied, as per IEC 60287:

**Table 25 – Correction factor for depth different than 1 m in the case of MV underground cables**

Depth (in m.)	Directly buried cables of cross section		Cables buried in duct of cross section	
	≤ 185 mm <sup>2</sup>	>185 mm <sup>2</sup>	≤ 185 mm <sup>2</sup>	>185 mm <sup>2</sup>
0.50	1.06	1.09	1.06	1.08
0.60	1.04	1.07	1.04	1.06
0.80	1.02	1.03	1.02	1.03
1.00	1.00	1.00	1.00	1.00
1.25	0.98	0.98	0.98	0.98
1.50	0.97	0.96	0.97	0.96
1.75	0.96	0.94	0.96	0.95
2.00	0.95	0.93	0.95	0.94
2.50	0.93	0.91	0.93	0.92
3.00	0.92	0.89	0.92	0.91

6. Open air installations

- 6.1. The maximum current in steady operation shall be determined based on the base installation: dry insulation installation up to 18/30 kV composed of three single-pole cables, bundled in contact, deployed in a way that allows good airflow, protected from the sun and with ambient air temperature of 40 °C.
- 6.2. The calculation of the maximum current shall be adapted to each particular situation to ensure that the maximum temperature generated by the calculated current is not higher than the one stipulated in Point 2 of this Article.
- 6.3. Maximum steady operation current (A.) for the base installation with copper conductor, as per IEC 60287:

**Table 26 – Maximum steady operation current for the base installation of MV cables in open air installations**

Conductor cross section (mm <sup>2</sup> )	EPR	XLPE	HEPR
25	140	155	160
35	170	185	195
50	205	220	230
70	255	275	295
95	310	335	355
120	355	385	410
150	405	435	465
185	465	500	535
240	550	590	630

#### 6.4. Correction factors for open air installations

##### 6.4.1. Correction for air temperature

- a) Where the average temperature of the air is different than 40 °C, the following correction factor F shall be applied to direct buried cables depending on the maximum temperature for the conductor ( $\theta_s$ ), as per IEC 60287:

**Table 27 – Correction factors for air temperature for MV cables in open air installations**

$\theta_s$ (°C)	Air temperature ( $\theta_a$ in °C)										
	10	15	20	25	30	35	40	45	50	55	60
105	1.21	1.18	1.14	1.11	1.07	1.04	1	0.96	0.92	0.88	0.83
90	1.27	1.23	1.18	1.14	1.10	1.05	1	0.95	0.89	0.84	0.78
70	1.41	1.35	1.29	1.23	1.16	1.08	1	0.91	0.82	0.71	0.58
65	1.48	1.41	1.34	1.27	1.18	1.10	1	0.89	0.78	0.63	0.45

- b) The correction factor F for temperatures other than those in the table shall be:

$$F = \sqrt{\frac{\theta_s - \theta_a}{\theta_s - 40}}$$

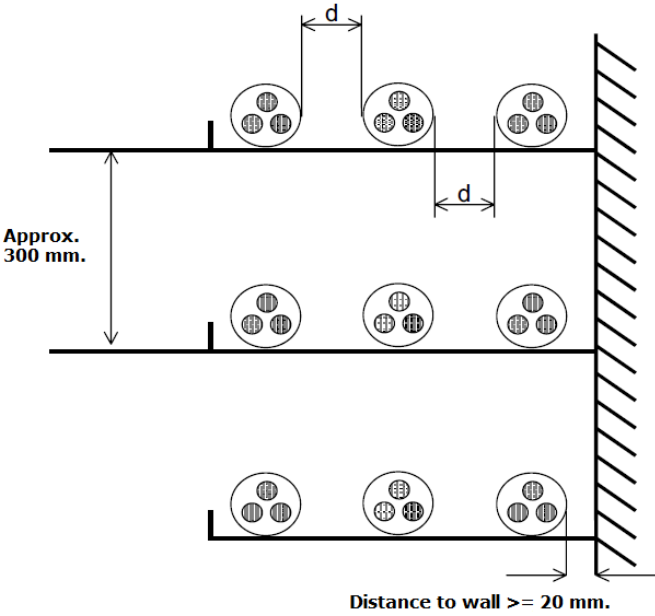
##### 6.4.2. Correction for distribution of the cables

- a) Three-pole cables or triplets of single-pole cables lying on trays (where airflow is restricted), separated each other a distance of one diameter (d), as per IEC 60287:

**Table 28 – Correction factors for distribution of the cables for MV cables lying on trays in open air installations**

Number of trays	Number of 3-poles or triplets				
	1	2	3	6	9
1	0.95	0.90	0.88	0.85	0.84
2	0.90	0.85	0.83	0.81	0.80
3	0.88	0.83	0.81	0.79	0.78
6	0.86	0.81	0.79	0.77	0.76

**Figure 4 – Scheme of MV cables lying on trays in open air installations and reference distances considered**

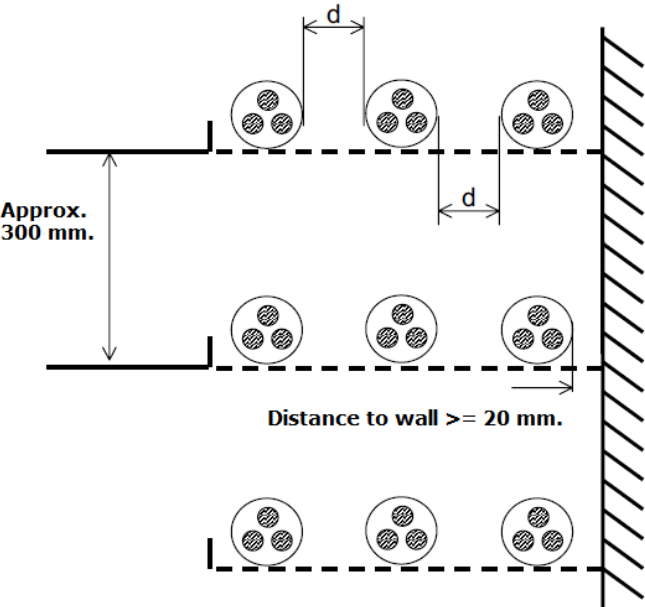


- b) Three-pole cables or triplets of single-pole cables lying on perforated cable trays, separated each other a distance of one diameter (d), as per IEC 60287:

**Table 29 - Correction factors for distribution of the cables for MV cables lying on perforated trays in open air installations**

Number of trays	Number of 3-poles or triplets				
	1	2	3	6	9
1	1	0.98	0.96	0.93	0.92
2	1	0.95	0.93	0.90	0.73
3	1	0.94	0.92	0.89	0.69
6	1	0.93	0.90	0.87	0.86

**Figure 5 - Scheme of MV cables lying on perforated trays in open air installations and reference distances considered**

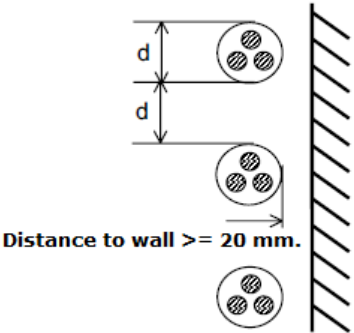


c) Three-pole cables or triplets of single-pole cables lying on structures or walls, separated each other a distance of one diameter ( $d$ ), as per IEC 60287:

**Table 30 - Correction factors for distribution of the cables for MV cables lying on structures or walls in open air installations**

Number of 3-poles or triplets	Correction Factor
1	1
2	0.93
3	0.90
6	0.87
9	0.86

**Figure 6 - Scheme of MV cables lying on structures or walls in open air installations and reference distances considered**

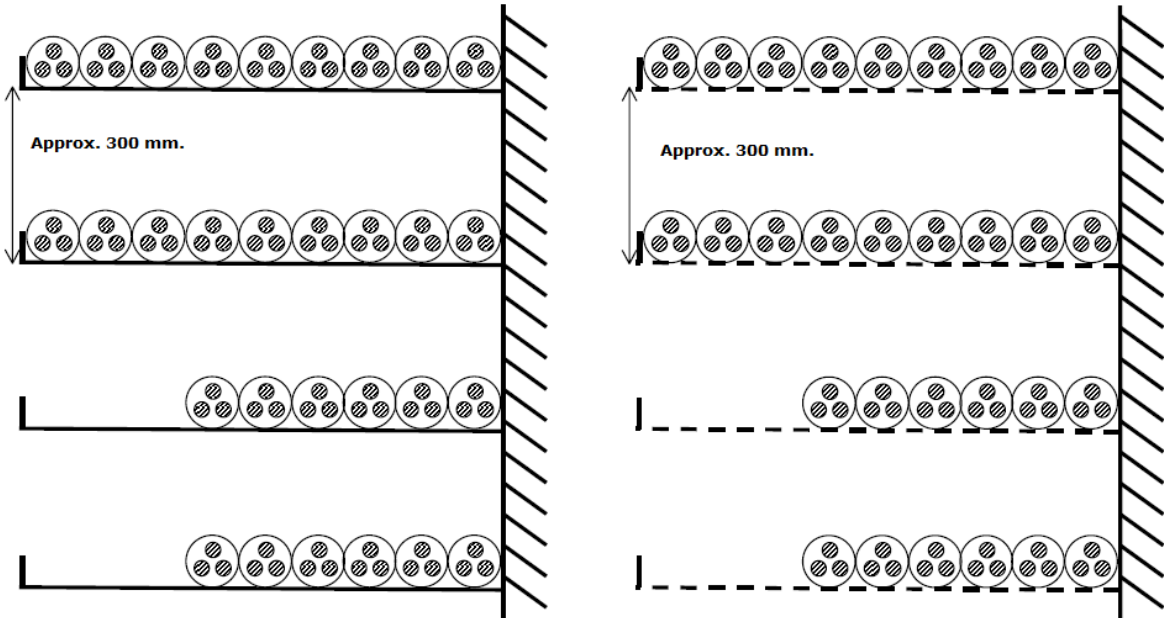


d) Three-pole cables or triplets of single-pole cables in contact between them and with the wall, lying on trays (where the airflow is restricted), as per IEC 60287:

**Table 31 – Correction factors for distribution of the cables for MV cables in contact between them and with the wall lying on trays in open air installations**

Number of trays	Number of 3-poles or triplets				
	1	2	3	6	9
1	1	0.84	0.80	0.75	0.73
2	1	0.80	0.76	0.71	0.69
3	1	0.78	0.74	0.70	0.68
6	1	0.76	0.72	0.68	0.66

**Figure 7 – Scheme of MV cables in contact between them and with the wall lying on trays in open air installations and reference distances considered**



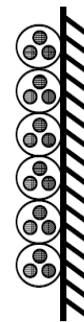
e) Three-pole cables or triplets of single-pole cables in contact between them, lying on a structure or wall, as per IEC 60287:



**Table 32 - Correction factors for distribution of the cables for MV cables lying on a structure or wall in open air installations**

Number of 3-poles or triplets	Correction Factor
1	0.95
2	0.78
3	0.73
6	0.68
9	0.66

**Figure 8 - Scheme of MV cables lying on a structure or wall in open air installations**

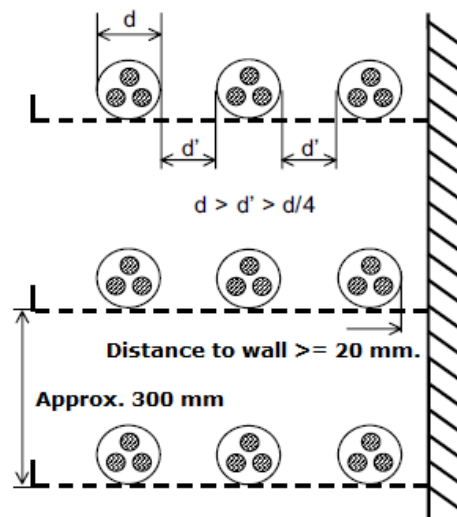


- f) Three-pole cables or triplets of single-pole cables with separation between them ( $d'$ ) shorter than a diameter ( $d$ ) and longer than a quarter of diameter, assuming perforated tray where airflow is adequate, as per IEC 60287:

**Table 33 – Correction factors for distribution of the MV cables separated less than a diameter lying on a perforated tray in open air installations**

Number of trays	Number of cables laid in horizontal			
	1	2	3	>3
1	1.00	0.93	0.87	0.83
2	0.89	0.83	0.79	0.75
3	0.80	0.76	0.72	0.69
6	0.75	0.70	0.66	0.64

**Figure 9 – Scheme of distribution of the MV cables separated less than a diameter lying on a perforated tray in open air installations and reference distances considered**

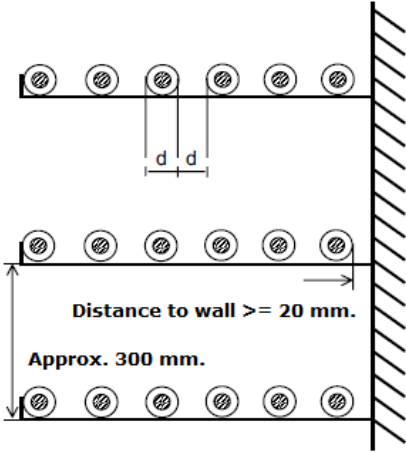


- g) Single-pole cables lying on continuous trays (restricted airflow) with separation between them equal to a diameter ( $d$ ), as per IEC 60287:

**Table 34 – Correction factors for single pole MV cables lying on continuous trays**

Number of trays	Number of triplets		
	1	2	3
1	0.92	0.89	0.88
2	0.87	0.84	0.83
3	0.84	0.82	0.81
6	0.82	0.80	0.79

**Figure 10 – Scheme of distribution of single pole MV cables lying on continuous trays and reference distances considered**

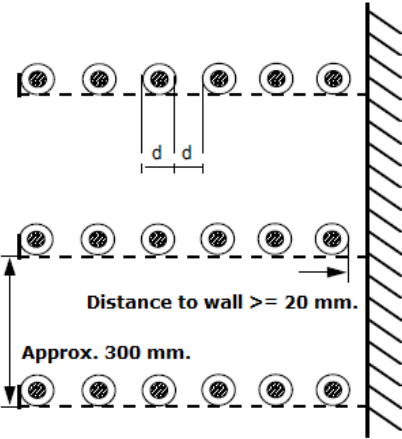


- h) Single-pole cables lying on perforated trays with separation between them equal to a diameter (d), as per IEC 60287:

**Table 35 – Correction factors for single pole MV cables lying on perforated trays**

Number of trays	Number of triplets		
	1	2	3
1	1.00	0.97	0.96
2	0.97	0.94	0.93
3	0.96	0.93	0.92
6	0.94	0.91	0.90

**Figure 11 – Scheme of distribution of single pole MV cables lying on perforated trays and reference distances considered**

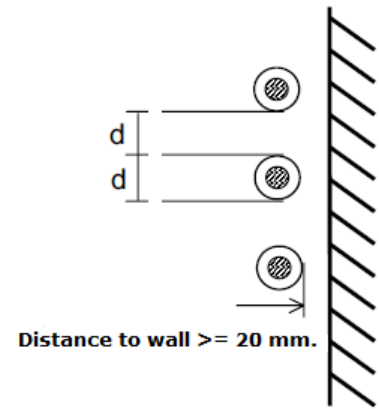


- i) Single-pole cables lying on a structure or wall at a distance (D) of at least 20 mm., one over the other, with separation between them equal to a diameter (d), as per IEC 60287:

**Table 36 – Correction factors for single pole MV cables lying on a structure or wall at a distance D of at least 20 mm**

Number triplets	Correction Factor
2	0.91
3	0.89

**Figure 12 – Scheme of distribution of single pole MV cables lying on a structure or wall at a distance D of at least 20 mm**

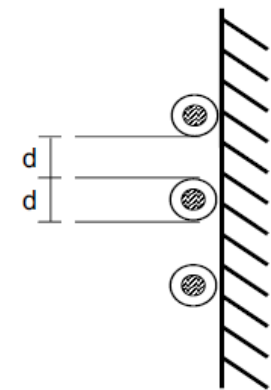


- j) Single-pole cables lying on a structure or wall at a distance smaller than 20 mm., one over the other, with separation between them equal to a diameter (d), as per IEC 60287:

**Table 37 – Correction factors for single pole MV cables lying on a structure or wall at a distance smaller than 20 mm**

Number triplets	Correction Factor
2	0.86
3	0.84

**Figure 13 – Scheme of distribution of single pole MV cables lying on a structure or wall at a distance smaller than 20 mm**



6.4.3. Correction for direct exposition to sun rays

- a) A correction factor of 0.9 shall be applied where the cables are exposed to direct sun irradiation.

## 7. Maximum admissible short-circuit current

### 7.1. Maximum admissible short-circuit currents for conductors

7.1.1. The maximum current allowed to pass through a conductor during short-circuits shall be calculated taking as initial temperature the steady operation temperature ( $\Theta_s$ ) and as final temperature the maximum temperature after 5 seconds of short circuit ( $\Theta_{sc}$ ) as per Point 2 of this Article. Given that the mass of the conductors is very big against the heat exchange surface and the duration of the process is relatively short, the process should be considered adiabatic.

7.1.2. The maximum short-circuit currents for copper conductors shall be the ones indicated in the following table, as per IEC 60287, or as indicated by the manufacturer:

**Table 38 – Maximum short-circuit currents for MV copper conductors by type of insulation**

Type of Insulation	$\Delta\Theta^*$ (K)	Duration of the short-circuit, $t_{sc}$ , in seconds									
		0.1	0.2	0.3	0.5	0.6	1.0	1.5	2.0	2.5	3.0
PVC – section $\leq 300 \text{ mm}^2$	90	240	170	138	107	98	76	62	53	48	43
XLPE, EPR	160	298	211	172	133	122	94	77	66	59	54
HEPR	145	281	199	162	126	115	89	73	63	56	51

*\*Spread of temperature between the initial temperature and the short-circuit temperature*

### 7.2. Maximum admissible short-circuit currents for screens

7.2.1. The maximum admissible short-circuit current in cables' screens considerably vary depending on the construction and composition of the cable. The maximum short circuit shall be calculated following the manufacturer recommendations and in any case the screen shall withstand a current of 1,000 A. during 1 second.

## Article 40. Minimum installation distances at crossings and parallelisms

1. It is forbidden to build edifications or plant trees within a distance of 150 mm at each side of the lateral walls of the trench of an underground cable.
2. Where underground cables cross through streets and roads, the cable shall be ducted and the duct installation shall be adequately covered and protected. The upper side of any of the cables shall be at least 0.6 m. under the ground level.
3. Whenever possible, at the crossing of underground cables, those with higher voltage shall be deployed deeper than those of lower voltage.

4. Where a MV underground cable crosses or runs parallel to another underground cable, the minimum distance between any of their cables shall be 0.25 m and the distance of the crossing point to the joints of any of the cables shall be at least 1 m. In case this is not possible, the cable most recently installed shall be covered by a protective duct or panel with a compressive strength of at least 450 N. and able to withstand an impact of 20 J. for diameters of the duct not larger than 90 mm., 28 J. for diameters larger than 90 mm. and not larger than 140 mm. and 40 J. for diameters larger than 140 mm.
5. The minimum distance between a MV underground cable and telecommunication cables shall be 0.20 m and 1m. between the crossing point and any of the joints of the cables. In case this is not possible, the most recently installed cable shall be covered by a protective duct or panel with a compressive strength of at least 450 N. and able to withstand an impact of 20 J. for diameters of the duct not larger than 90 mm., 28 J. for diameters larger than 90 mm. and not larger than 140 mm. and 40 J. for diameters larger than 140 mm.
6. Where a MV underground cable crosses or runs parallel to a water pipe, the minimum distance between any of the cables and the water pipe shall be 0.2 m and the distance of the crossing point to the joints of any of the cables and the joints of the water pipe shall be at least 1 m. In case this is not possible, the cable or pipe most recently installed shall be covered by a protective duct or panel with a compressive strength of at least 450 N. and able to withstand an impact of 20 J. for diameters of the duct not larger than 90 mm., 28 J. for diameters larger than 90 mm. and not larger than 140 mm. and 40 J. for diameters larger than 140 mm.
7. Where a MV underground cable crosses or runs parallel to a gas pipe, the minimum distance between any of the cables and the gas pipe shall be 0.40 m. In case this is not possible, the minimum distance can be reduced to 0.25 m. if additional protective solutions are installed. Such protective solutions shall be preferably ceramic and shall provide protection for at least 0.45 m. at each side of the crossing alongside the cable and 0.15 m. at each side of the centre of the cable. In case the cable is already protected by a duct, the aforementioned minimum protective distances shall not apply but the protective duct shall have a compressive strength of at least 450 N. and able to withstand an impact of 20 J. for diameters of the duct not larger than 90 mm., 28 J. for diameters larger than 90 mm. and not larger than 140 mm. and 40 J. for diameters larger than 140 mm.
8. Where an MV underground cable crosses a fuel tank, each of the cables shall be protected by a duct with a compressive strength of at least 450 N. and able to withstand an impact of 20 J. for diameters of the duct not larger than 90 mm., 28 J. for diameters larger than 90 mm. and not larger than 140 mm. and 40 J. for diameters larger than 140 mm. The duct shall cover the cable at least 2 metres before and 2 metres after crossing the tank.
9. In any of the above situations, where any of the underground cables, telecommunication cables, water pipes or gas pipes that are crossing or run parallel is a service drop, the minimum distance between them shall be 0.30 m. In case this is not possible, the installation (cable or pipe) most recently installed shall be covered by a protective duct or panel with a compressive strength of at least 450 N. and able to withstand an impact of 20 J. for diameters of the duct not larger than 90 mm., 28 J. for diameters larger than 90 mm. and not larger than 140 mm. and 40 J. for diameters larger than 140 mm.

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## Section 2. Standards for MV Switchgear and Control Gear

### Article 41. Connections and switching

1. MV switchgear and controlgear shall comply with the technical requirements imposed by the international standard IEC 62271.
2. Connection and switching of MV overhead lines shall always be made at the points where the lines meet a support structure.
3. Derivation, i.e. secondary lines connected to the main line, shall be equipped with a switching element; which shall be installed at the same support structure where the connection is made.
4. Switchgear installed at the connection of a derivation to the main line can be either a circuit breaker, a switch-disconnector or a disconnector depending on whether or not it is required to be able to open under load (understood as currents not lower than 0.5 A).
5. Switch-disconnectors and disconnectors can be:
  - 5.1. either automatic or manually operated.
  - 5.2. either single pole or 3-pole. For voltage levels higher than 30 kV only 3-pole switchgear shall be installed.
6. In overhead lines, switchgear shall be installed at a minimum height of 5 m. and be inaccessible for operation by other than the authorized staff.
7. The specifications of switchgear shall be adequate to withstand the voltage and current levels that can be experienced in the lines where they are installed and their contacts shall be dimensioned for a current of at least 200 A.
8. Where two source lines are available, a 3-pole switch shall be installed to change from one source to the other, making it impossible to feed from two sources at the same time.

## Section 3. Protections Requirements

### Article 42. Overcurrent protection

1. Overhead lines and underground cables shall be duly protected against the adverse thermal and dynamic effects, which currents higher than the nominal that can appear in the installation can produce whenever those effects may lead to having the line or cable out of service or damaged.
2. Heads of lines shall be protected against short-circuits and against overloads. This shall be achieved by installing circuit breakers or fuses at the beginning of the lines.
3. The characteristics and configuration of the protection equipment shall be adapted to the overall requirements imposed on the installation where they actuate.
4. Protection equipment shall not explode or project dangerous materials or substances during their operation that can damage persons or assets.



5. Protection solutions shall be configured and coordinated to disconnect the minimum possible network section or load in case of short-circuit or overloading.
6. Where the individual disconnection of a single phase of the circuit may generate ferroresonance or other adverse effects, three-phase protection solutions shall be installed.
7. Short-circuit protection:
  - 7.1. Short-circuit protection shall be achieved through the installation of fuses or circuit breakers capable of clearing the fault in a time such that the temperature on the lines does not overshoot the maximum allowed during short-circuits.
  - 7.2. The maximum short-circuit currents allowed are those indicated in this Electrical Installation Standards. Higher short-circuit currents can be allowed if justified to the satisfaction of the URA based on manufacturer's specifications.
8. Overcurrent protections shall comply with the requirements of IEC 62271 and IEC 60071.

#### **Article 43. Overvoltage protection**

1. Lines and cables shall be protected against overvoltages due to internal or atmospheric causes whenever the relevance of the installation, the relevance of the overvoltage or its frequency justify it.
2. Overvoltage protections shall comply with the requirements of IEC 62271 and IEC 60071.

## **Section 4. General Guidance for HV Installations**

#### **Article 44. Preliminary approach to HV installations**

1. The construction and operation of Electrical Installations of nominal voltage higher than 35 kV (HV) shall require the approval of the URA.
2. Unless otherwise approved by the URA, HV Electrical Installations shall be limited to the interconnection of electric systems of different islands where the energy flow required and the distance to be overcome justify it.
3. Prior to the construction and operation of HV Electrical Installations, the promoter of the HV Electrical Installation shall evaluate the impact that such developments could have on the existing MV and LV system and what modifications to the existing installations are required. This analysis shall be compiled in a report sent to the URA for information and evaluation purposes.
4. Prior to the construction and operation of HV Electrical Installations, the URA shall approve the technical and operational requirements that shall apply to the mentioned installations.

#### **Article 45. List of international standards for HV installations**

HV Electrical Installations shall be constructed and operated in compliance with the following international standards:

1. IEC 60183: Guide to the selection of high voltage cables.
2. IEC 62271: High voltage switchgear and controlgear.
3. IEC 60815: Selection and dimensioning of high voltage insulators intended for use in polluted conditions.

## Section 5. Requirements for MV Transformers

### Article 46. Technical specifications of MV Transformers

All MV Transformers designed to install in the Maldives shall conform to the following parameters

#	Parameter	Value
1	Compliant International Standard	IEC 60076-1
2	Low Voltage Winding Material	Copper
3	Medium Voltage Winding Material	Copper
4	Frequency (Hz)	50 Hz
5	Vector group	Dyn11
6	Paint Class	C5 (ISO 12944-5)

### Article 47. Installation requirements of MV Transformers

1. The minimum clearance around an MV transformer shall be 1.6 meters
2. Base of the transformer shall be mounted at a minimum of 500 mm above the ground level to reduce potential for inundation
3. All termination points with bare conductors shall be fitted with insulating flexible bushing/boots or heat shrink which confirms to IEC 60502-4 or a similar international standard
4. No interior installations of MV transformers shall be entertained. If such an installation is required, prior written approval shall be obtained from the relevant institution for fire safety and the URA.
5. An earthed cage, or similar structure shall be erected around the clearance as to restrict access to unauthorized personnel, prevent vandalism and accidents.
6. Cables from and to the transformers shall be in ducts or in an arrangement such that it does not obstruct pathways.
7. The transformer identification shall be clearly visible on the transformer.
8. The data plate of the transformer shall be mounted at a convenient location.
9. A scaled network diagram shall be mounted nearby to the transformer with the transformer clearly marked.
10. A Single Line Diagram of the MV network shall be mounted nearby to the transformer with the transformer clearly marked.
11. Class 2 Insulation gloves in compliance with IEC 60903 should be available in close proximity to the transformer and shall be worn when carrying out any work on the transformer.

## CHAPTER VI. STANDARDS FOR GENERATING STATIONS

### Section 1. General Provisions

#### Article 48. General provisions for installations of Generating Stations

1. Generating Stations, regardless of their size or technology, shall comply with the provisions of this Electrical Installation Standards and any other applicable regulation approved by the URA.
2. The connection of Generating Stations to a Distribution Network shall be approved by the Service Provider in charge of the operation of that Distribution Network.
3. Design and constructive characteristics of Generating Stations shall be such that allow them to comply with the operational and safety requirements imposed by this Electrical Installation Standards or other applicable regulation during normal operation and during exceptional events.
4. All generator units shall be clearly labelled with:
  - 4.1. Name of the manufacturer;
  - 4.2. Model of the generator unit; and
  - 4.3. Date of manufacture or code that allows to trace it.
5. The owner of the Generating Station shall have a plan of at least:
  - 5.1. The location and the environments of the Generating Station. A scale of 1:1000 is advised, indicating accesses to the premises and references easy to identify.
  - 5.2. The location of the main elements of the Generating Station (generating equipment, main lines and cables and their support structure, buildings and transformers). A scale of 1:200 is advised.
  - 5.3. Structural elements of the generating engine or module, clearly indicating its parts or components and the way they fit together. A scale from 1:20 up to 1:50 is advised.
  - 5.4. Electromechanical components of the generating engine or module, clearly indicating its parts or components and the way they fit together. A scale from 1:20 up to 1:50 is advised.
  - 5.5. Foundation and earthing solution implemented, if any.
  - 5.6. Single line diagram of the electrical installation, indicating the main electric magnitudes (voltage level and currents).
  - 5.7. Block diagram of the control system implemented, if any.
  - 5.8. The transformer centre, if any. Both single line diagrams and construction planes (plan and elevation) where the building and the transformers are clearly presented in location and dimensions. A scale of 1:20 is advised.
  - 5.9. Floor plan of the control building, if any, indicating the location of main equipment there installed. A scale from 1:20 up to 1:50 is advised.

- 5.10. Underground MV cable installations. A scale of 1:500 is advised.
- 5.11. Underground LV cable installations. A scale of 1:500 is advised.
- 5.12. Underground ducts present in the premises (electric and non-electric, such as water, gas or fuel pipes). A scale of 1:500 is advised.
- 5.13. Cross section of the distribution of underground MV cable installations. A scale of 1:20 is advised.
- 5.14. Cross section of the distribution of underground LV cable installation. A scale of 1:20 is advised.

#### **Article 49. Location, environmental and safety requirements**

1. Power houses where rotating engines are installed shall be located at least 100m away from residential areas to prevent disturbance to population from sound and smoke or emissions. For new power houses, the power house can be located at shorter distances where adequately justified through installation of specific measures to control threats or impacts to population, or where the required space is not available in the island. For existing power houses, all mitigation measures should be taken to minimize or eliminate impacts on pollution. In any case, the location for new power houses shall have to be approved by the URA.
2. Power generating facilities shall not emit audible noise over a maximum peak of 100 dBA nor in 8hrs time weighted average over 65 dBA at the boundary and 70 dBA at 1m from the powerhouse, measured at the physical limit of the facility. Appropriate signage should be displayed in areas where sound levels exceed 80 dBA.
3. Power houses shall be equipped with an adequate amount of hard helmet and hearing protection with a minimum Single Number Rating (SNR) of 30 dBA, located inside the power house and near the main entry so that it is readily accessible for its use by any visitor to the power house.
4. There are no restrictions to the location of generating solutions without rotating engines such as solar photovoltaic panels, but the installation still has to be approved by the URA or the parties authorized to do so by the URA.
5. Emergency instruction and first aid procedures must be displayed at different locations in the power house to cater for a possible event of electrocution in the control room or in the engine room. They shall at least be available next to the entrance, in the inside of the room where the generating engine is located and in the control room.
6. Suitable fire extinguishers must be installed in an easily accessible manner for the use of the control room staff and the engine room staff.
7. Emergency exits shall be clearly marked with display signs, location of fire extinguishers and fire escape routes; the latter shall be clearly indicated in a map displayed at the entrance. Emergency Lights shall be placed above exits in every room of the building.

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**Article 50. Testing requirements**

1. All Generating Stations shall undergo tests prior to their safe steady operation. Such tests shall include but not be limited to:
  - 1.1. Safe start-up;
  - 1.2. Safe shutdown;
  - 1.3. Safe emergency shutdown;
  - 1.4. Safe shutdown from overspeed or representative simulation thereof (in case of rotating engines); and
  - 1.5. Function test of protection system, security system and alarms.
2. All prime elements of a Generating Station (metering equipment, generating engine or generating modules and transformers and inverters, if any) shall be accompanied by proof of successful manufacturer tests.

**Section 2. Particular Aspects for Renewable Plants****Article 51. Specific requirements for Renewable Plants**

Where the Generating Station is a Renewable Plant, the following specific requirements shall be observed:

1. PV panels:
  - 1.1. PV panels shall be equipped with bypass diodes to avoid damages to the cells and circuits due to partial shading and be at least of class IP 65.
  - 1.2. In case the PV panels are enclosed in a border framework, this should be made in aluminium or stainless steel.
  - 1.3. Each PV panel string shall be equipped with switchgear (fuses, disconnectors, etc.) as required to allow its individual isolation from the other panels that may be present in the installation.
2. Wind farms:
  - 2.1. In case the wind turbine has a step-up transformer installed inside the nacelle or the tower, it shall be a dry-type transformer.
3. Inverters:
  - 3.1. Inverters shall be self-commutated.
  - 3.2. Inverter shall automatically follow the point of maximum output of the generator.
  - 3.3. Inverters shall be equipped with the following protections:
    - 3.3.1. Alternate current short-circuits;
    - 3.3.2. Voltage out of range;
    - 3.3.3. Frequency out of range;
    - 3.3.4. Overvoltage;

- 3.3.5. Perturbations coming from the Distribution Network such as micro-interruptions, pulses and cycle defects (whenever connected to the Distribution Network).
- 3.3.6. Inverters shall be of at least IP 30 for inverters located inside buildings and IP 65 for inverters located outside.

## **Section 3. Main Installation Conditions**

### **Article 52. Constructive requirements**

1. Power generation rotating engines shall be located inside a power house which shall be constructed in cement, metal or materials with similar characteristics and be equipped with adequate sound and water insulation on the inside walls and roof. The inside of the power house must be kept clean at all times in order to prevent fire or other hazardous events.
2. Where the power generation engine requires an exhaust chimney, the height of the chimney shall be determined based on an appropriate scientific methodology that ensures no impact on nearby dwellings and their residences (for new power houses), and sufficient mitigation measures to eliminate the said impact for existing power houses. The said requirements must be met and verified as a part of the environmental assessment relevant to powerhouse or generating station.
3. Power generation rotating engines shall be installed on a foundation or structure designed to cater for the mechanical load created by the engine in operation. Anti-vibration mounting solutions shall be installed between the rotating engine and the foundation.
4. The power house shall be ventilated enough to maintain a maximum ambient temperature difference of at least 12 °C between the outside and the inside of the power house while all the engines there installed are running, meeting at least the manufacturers specifications.
5. Power house building, fuel handling, fuel storage, etc., shall be in accordance with the regulations of the relevant organization regarding these matters. If no such regulations exist, these matters must be handled after discussions with the relevant ministries and as per their advice. The conclusions of these discussions shall be obtained from the aforementioned ministries and communicated to the URA and endorsed.
6. Fire extinguishing facilities must be installed according to the requirements of the MNDF Fire and Rescue services.
7. To prevent fire incidences, sign boards prohibiting actions that might lead to fire must be mounted on the door and inside the power house where these can be clearly visible.
8. Emergency lights must be placed inside the power house, at the panel boards and at the control room to cater for working conditions in the event of a blackout at the facility.
9. Generating Stations that use fuel as source of energy shall comply with the following requirements:
  - 9.1. The main fuel tank for the generator may be installed either as a sub-base tank mounted under the generator set skid or as a remote fuel tank. In case of remote fuel tanks, an intermediate fuel tank, the day tank, shall be installed to properly supply the generator.

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- 9.2. Both the main storage tank and the day tank (if any) shall be installed within a dike wall or a rupture basin which prevents any fuel leakage or spillage from entering the soil or spreading out of the boundaries of the dike wall. The dike wall or the rupture basin shall delimit a volume with capacity to store 150% of the inner fuel tank capacity. The height of the dike wall, if any, shall be 80 cm where practical. Should the dike wall require more than 80cm, stairs can be incorporated into the dyke wall to allow viewing and going in and out of the dyke.
  - 9.3. The day tank shall be designed so that it can contain enough fuel for the generator set to continuously generate electricity at its nominal power for eight (8) hours. Although it may be possible that a same day tank supplies several generator sets, it is preferred that each generator set has its own independent day tank.
  - 9.4. The main fuel storage, the day tank or other fuel reservoir shall be arranged so that the highest level of fuel does not exceed the maximum height above the fuel injectors specified by the manufacturer. The lowest level must not fall below the maximum light height of the engine's fuel lift pump specified by the manufacturer.
  - 9.5. The main fuel storage and the day tanks shall be equipped with a mechanism for pumping or draining out water and sediments from the bottoms of the deposit.
  - 9.6. All fuel deposit, either the main fuel storage or any day tank, shall be filled so that a minimum expansion space of 5% of the volume is left to prevent spillage when the fuel warms up.
  - 9.7. The main fuel storage and the day tanks shall be equipped with vent caps in order to allow any pressure or vacuum in the tank to vent to the open air atmosphere. The vent caps shall be screened so that rain and external object cannot enter the tanks.
  - 9.8. The main fuel storage shall be filled with fuel through a fill pipe which is protected by a screened cap to prevent rain and external objects from entering the tank when the fuel tank is not being filled.
  - 9.9. The fuel lift pump, the day tank transfer pump (if any) or the float valve seat should be protected from fuel supply tank debris by a pre-filter or sediment bowl with a 100 to 120 mesh element.
  - 9.10. Separate fuel return lines to the day tank or the main storage tank shall be provided so that idle generator sets are not kept with pressurized fuel pipes.
  - 9.11. Connection of the main storage tank or the day tank with the generator set shall be made through flexible fuel hoses in order to withstand the generator's movement and vibration.
  - 9.12. The fuel piping system shall not run close to heating pipes, electrical wiring or engine exhaust system components. It shall include valves at appropriate locations to allow isolation of system components for repair without draining the entire fuel system.
  - 9.13. The main fuel storage and the day tanks shall undergo external inspection every five (5) years and internal inspection every ten (10) years. The inspection shall be done by an independent party or by URA.
10. Internal combustion engines shall meet the following requirements regarding crankcase ventilation:

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- 10.1. The crankcase of internal combustion engines shall be equipped with a crankcase ventilation system which can be either ingestive (which vents the blow-by into the engine where it returns to the combustion cycle) or non-ingestive (where the blow-by is vented to the atmosphere).
  - 10.2. Crankcase ventilation, either ingestive or non-ingestive, shall be designed as per the instruction of the manufacturer of the generator engine.
  - 10.3. Each generator unit shall be equipped with an independent crankcase ventilation system.
  - 10.4. In case of non-ingestive crankcase ventilation:
    - 10.4.1. the blow-by shall be conducted to open air through a piping system;
    - 10.4.2. the exit of the crankcase ventilation system to open air shall be protected to prevent rain and external objects to enter the crankcase ventilation system;
    - 10.4.3. crankcase emissions shall not be discharged into the air ventilation system because the oil layer that would be created leads to fire hazard and can damage equipment; and
    - 10.4.4. a drip collector shall be installed near the engine, connected to the crankcase ventilation pipe in order to collect condensed combustion products and avoid their exhaust to the atmosphere.
  11. The generator shall be equipped with fuel meters that measure the volume of fuel consumed by the generator from any fuel inlet to the generator and any fuel return lines from the generator.

### **Article 53. Lightning protection requirements**

1. Buildings or cabins where power generators are installed shall be protected against atmospheric lightning strikes by means of a lightning protection system whose area of protection cover the whole building or cabin. In case this is not possible, all metallic elements out of the protection area shall be directly earthed through a copper conductor of at least 65 mm<sup>2</sup> connected to a copper rod of at least 65 mm<sup>2</sup> and 2 m long.
2. Air terminations of the lightning protection system shall be designed and located following the protection angle method to achieve a level of lightning protection capable of withstanding discharges of at least 50 kA.
3. Overvoltage protection systems shall be installed at the entrance or exit of each circuit of electrical lines to the building or cabin where the generating unit is installed.
4. Lightning protection should cover the following buildings/equipment:
  - 4.1. Powerhouse
  - 4.2. Fuel Tanks
  - 4.3. Transformers



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**Article 54. Electrical installation requirements**

1. The wiring in the power house shall be identified in accordance with IEC 60445 or the standard that replaces it.
2. Wiring, busbars, and any other major conductors shall be made in copper with the capacity adequate to wheel the required currents with reduced voltage drops (not higher than 1.5%).
3. The wiring diagram panel shall be mounted in the control room.
4. The switchboard must include and fulfil the following:
  - 4.1. At least one main switch circuit breaker;
  - 4.2. An incomer indicator light must be installed;
  - 4.3. Ability to measure the current in each of the phases to which the installation is connected;
  - 4.4. Ability to measure the generator's frequency;
  - 4.5. Ability to measure the generator's power output (kW);
  - 4.6. Ability to measure the generator's energy output (active and reactive, that is, kWh and kVARh);
  - 4.7. Be equipped with earth fault protection;
  - 4.8. If more than one generator is being used, it must have a synchronization panel or must have a changeover switch that can cater for 125% of the rated current of the largest generator.
5. All metallic elements of an installation that are not usually under voltage, but may be due to faults, accidents, overvoltage's or atmospheric discharges shall be connected to the protective earth (earthed or grounded). This provision includes inter alia:
  - 5.1. The casing, chassis and racks of switching devices;
  - 5.2. The casing or envelope of metallic cabinets;
  - 5.3. Metal doors in the premises;
  - 5.4. Metal fences;
  - 5.5. Metallic screens of cables;
  - 5.6. Metallic columns, arches and other support structures.
  - 5.7. Pipes and metallic ducts;
  - 5.8. The cases of generator engines, transformers, turbines and other machines;
6. Generators shall have their neutral connected to earth through high impedance.
7. Any equipment that requires it for its functioning shall be connected to earth (such as the neutral of alternators, the low voltage circuits of current transformers and voltage transformers that require it, surge arresters, the earthing derivate of earthing switches and disconnectors, etc. All equipment shall be of protection Class I as per IEC 61140.

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**Article 55. Reference Standards**

The installation of Generating Stations shall be guided by the IEC standards applicable to each type of generator. In particular, the following standards shall serve as reference:

1. Power transformers: IEC 60076;
2. PV Generating Stations: IEC 60904;
3. Wind Generating Stations: IEC 61400;
4. Steam turbines: IEC 60045; and
5. Rotating generator engines: IEC 60034.

**Section 4. Main Electrical Connection Conditions****Article 56. Protection solutions**

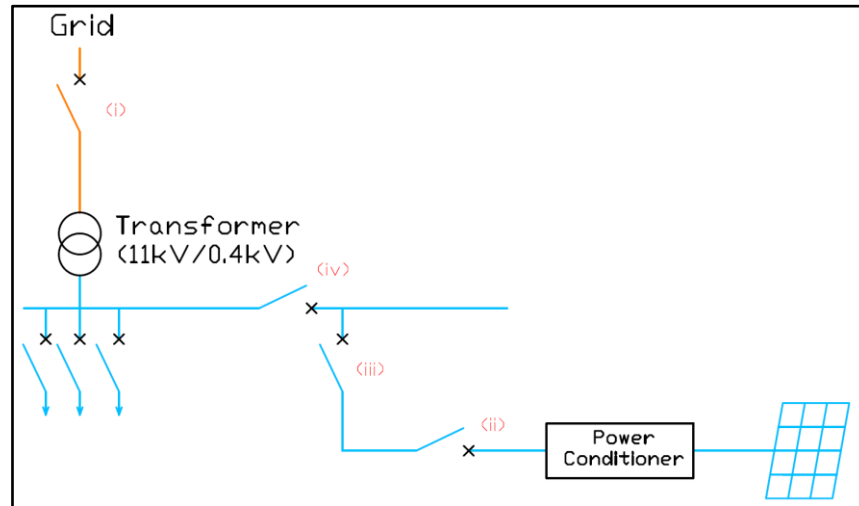
1. At least the following protection relays shall be installed at the connection point or at a point where fault can be detected (an outlet of the Generating Station, a communication bus between the connection point and the Generating Station or the secondary side of the power receiving transformer, if any):
  - 1.1. Over-voltage relay;
  - 1.2. Under-voltage relay;
  - 1.3. Over-frequency relay; and
  - 1.4. Under-frequency relay;
  - 1.5. Where reverse power flow is prohibited, a reverse power relay shall be installed.
2. Under-frequency, over-frequency and reverse power relays shall be installed in a single phase. Under-voltage and over-voltage relays shall be installed in each of the phases to which the Generating Station is connected.
3. Generating Stations connected to the MV Distribution Network shall be equipped with Loss of Mains protection to detect islanding situations and turn off the prime mover of the installation. Islanding operation detection shall have at least an active type detection mechanism and a passive type detection mechanism selected from the following table:

**Table 39 – Possible types of islanding operation detection mechanisms**

<b>Active Type</b>	<b>Passive Type</b>
Frequency shift type	Power phase jump detection type
Active power fluctuation type	3 <sup>rd</sup> harmonic voltage rise detection type
Reactive power fluctuation type	Frequency change rate detection type
Load fluctuation type	

4. If the Generating Station is equipped with automatic recovery function after blackout, the function shall be configured with the condition of receiving voltage confirmation to prevent the damage by unnecessary parallel-in with the Distribution Network.
5. All circuit breakers intended to separate the Generating Station or the generating modules from the Distribution Network shall provide effective mechanic insulation from the Distribution Network supply, switches composed of semiconductors are not allowed for this task.
6. In case any of the protection devices mentioned in Point 1 of this Articles trips, the Generating Station shall be paralleled off from the Distribution Network at any of the following points:
  - 6.1. Main circuit breaker (i);
  - 6.2. Generator output breaker (ii);
  - 6.3. Generator communication breaker (iii); or
  - 6.4. Bus communication breaker (iv).

**Figure 14 – Possible points where a Generating Station shall be paralleled off by the action of protection relays**



## Section 5. Operation Modes

### Article 57. Operation Modes

1. Generating Stations can operate in one or several of the following operation modes:
  - 1.1. Normal operation modes
    - 1.1.1. Continuous parallel operation
    - 1.1.2. Peak reduction operation
    - 1.1.3. Automatic mains failure operation
    - 1.1.4. Standby generator
  - 1.2. Exceptional operation modes
    - 1.2.1. Testing
    - 1.2.2. Emergency
2. Generation Stations shall communicate to the URA and to the Operator of the Distribution Network to which they are connected (where applicable) the preferred operation mode for each of their generator units prior to the commissioning of the facilities.
3. Generation Stations shall communicate as soon as reasonably feasible any change in their operation mode to the URA and to the Operator of the Distribution Network to which they are connected.

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**Article 58. Characteristics of each operation mode**

1. Continuous parallel operation
  - 1.1. The generator operates in parallel with the Distribution Network in an unrestricted way, that is, in synchronism with and injecting power into the Distribution Network.
  - 1.2. Depending on the characteristics of the Generating Station, it shall communicate or not the expected output levels to the Operator of the Distribution Network.
2. Peak reduction operation
  - 2.1. The generator only injects power into the Distribution Network during limited period of time. During off-peak period the generation remains idle or at least remains idle from the point of view of the Distribution Network because it is not injecting power into the Distribution Network. Peak reduction operation also includes the generators that operate during maximum demand period of an Electrical Installation to cover up for or complete the power that cannot be withdrawn from the Distribution Network.
3. Automatic mains failure operation
  - 3.1. Upon loss of main supply (loss of power from the Distribution Network) the generators operate in islanded mode. That is, the generator injects power to a section of the Distribution Network that is separated from the main Distribution Network.
  - 3.2. This is an unstable situation that can damage the generator if it continues operating as in continuous parallel operation and therefore it is not allowed and generator's prime mover shall be turned off.
4. Standby generator
  - 4.1. Standby generators remain connected to the electric installation or network they are supposed to supply but without injecting any power into it. They are ready for promptly entering into operation injecting power in case of outage in the electric installation or network, which are typically supplied from the Distribution Network or from another generator.
  - 4.2. Standby generator are typically diesel generator equipped with an automatism that detects loss of main supply, starts the standby generator and switches supply to it.
5. Testing
  - 5.1. Generators in testing operation mode answer to specific operation signals entered by the personnel in charge of conducting the tests. Some of these test require the generator to be connected to the Distribution Network and other do not.
  - 5.2. Generators undergoing tests present unpredictable and potentially dangerous behaviour and thus they shall be closely monitored to prevent damages to assets or persons.
  - 5.3. Prior to conducting tests that may imply the modification of the normal operation of the generator, approval from the Operator of the Distribution Network shall be obtained as per the Service Providers Code.
6. Emergency
  - 6.1. During emergency situations (either internal to the Generating Station or external) generators may be forced or requested to operate under abnormal conditions for a limited duration, until the emergency disappears.
  - 6.2. During emergency situations Generating Stations may be requested by the Operator of the Distribution Network to which they are connected to modify their output levels and they shall abide.

## **CHAPTER VII. INSPECTION AND VERIFICATION**

### **Section 1. Initial and periodic inspections and verifications**

#### **Article 59. Inspection and verification requirements**

1. All Electrical Installations shall undergo inspection by the URA or the agent authorized by the URA in two timeframes:
  - 1.1. Initial inspections: verifications prior to the commissioning of the Electrical Installation.
  - 1.2. Periodic inspections: verifications during the useful life of the Electrical Installation at regular intervals.
2. All Electrical Installations shall undergo initial verification prior to their commissioning by the authorized installer.
3. The authorized installer, authorized by the URA, shall be responsible for the proper execution of the installation, granting its safety.
4. The owners of an Electrical Installation shall be responsible for their maintenance in good and safe operating conditions.

#### **Article 60. Frequency of Inspections**

1. All Electrical Installations with MIC or MEC higher than 500 kW shall undergo periodic inspection by the URA or its authorized agents at least once every five (5) years.
2. All Electrical Installations with MIC or MEC equal or lower than 500 kW shall undergo periodic inspection by the URA or its authorized agents at least once every ten (10) years.
3. The URA may perform inspections at any given moment if so required to comply with its regulatory functions and subject to notifying in writing the owner of the Electrical Installations to be inspected at least fourteen (14) Days in advance.

#### **Article 61. Types and characteristics of verifications**

1. Verification activities shall be performed in a two-step approach:
  - 1.1. Verification by examination.
  - 1.2. Verification by measure
2. The verification by examination:
  - 2.1. Shall be performed prior to the verification by measure;
  - 2.2. Shall cover the whole Electrical Installation and while it is not energized, unless specifically requested.
  - 2.3. Shall verify the following:

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- 2.3.1. Whether the material and equipment installed are actually in accordance with the provisions and requirements of the technical project design;
  - 2.3.2. Whether the material and equipment have been installed following the prescriptions and requirements of this Electrical Installation Standards and the manufacturer's recommendations;
  - 2.3.3. Whether the material and equipment installed present any fault or visible defect which may impact safety of persons or equipment and materials;
  - 2.3.4. In particular, verifications by examination shall include:
    - a) Verification of the protective measure against Electric Shock installed, either by direct contact or by faults in the insulation of live parts;
    - b) The presence, condition and calibration of protective and signalling devices;
    - c) The presence and condition of protections against thermal effect and fires;
    - d) The use of adequate materials and measures to protect the Electrical Installation against external agents;
    - e) The presence and characteristics of schemes, panels and similar information tools to communicate dangers and safety measures to persons;
    - f) The location and characteristics of switchgear and relays;
    - g) The correct execution of wiring connections;
    - h) The adequate access to the Electrical Installation for inspection, operation and maintenance.
  3. The verification by Measure shall include at least:
    - 3.1. Verification of the continuity of protective wiring;
    - 3.2. Measurements of the earthing impedances;
    - 3.3. Measurements of the insulation level of conductors and other equipment;
    - 3.4. Measurement of the dielectric strength of transformers' oil and switchgear's oil (if any & where it is necessary),
    - 3.5. Verification of the phase sequence of alternate current systems; and
    - 3.6. Any other specific measurements recommended by the manufacturer or required by the regulation in force in the Republic of Maldives.
  4. Inspection and testing of low voltage Electrical Installations shall be based on the requirements of IEC 60364-6.
  5. Inspection and testing of medium voltage Electrical Installations shall be based on the requirements of IEC 60060 and the IEC standards applicable to each electrical equipment.

6. Inspection and testing of Generating Stations shall be based on the requirements of the IEC standard applicable to each type of generation equipment, notably:

- 6.1. Power transformers: IEC 60076;
- 6.2. PV Generating Stations: IEC 60904 and IEC 62446;
- 6.3. Wind Generating Stations: IEC 61400;
- 6.4. Steam turbines: IEC 60045; and
- 6.5. Rotating generator engines: IEC 60034.

#### **Article 62. Reporting on inspections and verifications**

1. After each inspection or verification action, the agent responsible for carrying out the inspection or verification shall submit to the URA (when the inspection or verification was not carried out directly by the URA's personnel) and to the owner of the Electrical Installation inspected or verified, an Inspection Report or Verification Report containing at least:
  - 1.1. Identification of the Electrical Installation inspected or verified;
  - 1.2. Name and stamp of the agent who performed the inspection or verification;
  - 1.3. Date and time the inspection or verification was performed;
  - 1.4. List and descriptions of the elements inspected or tested and the inspection or verification actions carried out;
  - 1.5. Detailed summary of the outcomes of the inspection or verification actions;
  - 1.6. Environmental conditions during the inspection or verifications and description of equipment utilised (if any); and
  - 1.7. Signature of at least a representative of each of the agents present during the inspection or verification.
2. The Inspection Report or Verification Report shall be sent to the URA and to the owner of the Electrical Installation in writing (soft or hard copy) no later than ten (10) Business Days after the finalization of the inspection or verification.

## **Section 2. On-demand inspections and verifications**

#### **Article 63. Procedure for inspection and verification on-demand**

1. The Service Provider, the owner of the electrical equipment, the Customer if different than the owner, or eventually the URA, can request on-demand that inspection and verification are performed on electrical equipment.
2. On demand inspection and verification activities shall comply with the same technical requirements set for initial and periodic verification activities.



3. The owner of the premises where the electrical equipment is located shall grant access to the electrical equipment to the parties involved: The Service Provider personnel, the Customer or its representatives, the URA or its representatives and any other agent that is involved in the inspection and verification activities.
  4. The agent that will carry out the inspection and verification activities shall present the other parties the characteristics of the activities to be performed, their objective, and the procedure that will be followed.
  5. In case of metering equipment:
    - 5.1. The Operator of the Distribution Network shall be in charge of sealing and unsealing it whenever necessary.
    - 5.2. In case the inspection and verification requires tests that cannot be performed in situ, the electrical equipment shall be removed by the Operator of the Distribution Network, packed and sealed, and sent to the place where the tests are to be performed.
    - 5.3. Immediately after removal of the meter, a substitute shall be installed by the Operator of the Distribution Network until the original is ready for its re-installation. Particular attention shall be put to the multipliers utilised by the meter in registering data from the CTs and VTs, if any.
  6. On demand inspection and verification activities shall be subject to the same reporting requirements as initial and periodic inspection and verification activities.
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