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ELECTRICAL SAFETY CODE – Code of Practice

Part 1: Construction, installation and commissioning rules

ZAMBIA BUREAU OF STANDARDS

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FOREWORD

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The revision of this Zambian Standard was undertaken to address the challenges faced and deficiencies observed during its implementation. Further, there was need to ensure that the Standard continued to meet the aspirations of the stakeholders in the Zambia Electricity Supply Industry (ESI). These reasons together with the need to be abreast with the advancements in technology necessitated the revision of the second edition of the standard (ZS 418-1:2013) which has been replaced by this third edition of ZS 418-1:2024.

ZS 418 has been divided in two parts as follows:

Part 1: Construction, installation and commissioning rules.

Part 2: Operations and maintenance.

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ZAMBIA BUREAU OF STANDARDS

Zambian Standard

ELECTRICAL SAFETY CODE - Code of Practice

Part 1: Construction, installation and commissioning rules

1 SCOPE

This part of ZS 418 covers rules for practical safeguarding of persons, animals, infrastructure and the environment from the hazards of electrical practices employed by a system during and after construction, installation and commissioning.

NOTE 1: These rules may be adopted with applicable rules for installations in mines, ships, locomotive systems, aircrafts, automotive equipment and hazardous environments.

NOTE 2: Rules pertaining to operations and maintenance are covered in ZS 418 - 2: 2024

2 NORMATIVE REFERENCES

The following documents contain provisions which, through reference in this text, constitute provisions of this Standard. All documents are subject to revision and, since any reference to a document is deemed to be the latest reference to the latest edition of that document, parties to agreements based on this Standard are encouraged to take steps to ensure the use of the most recent editions of the documents indicated below. Information on currently valid national and international documents may be obtained from the Zambia Bureau of Standards.

ZS 418 Part 2	Electrical Safety Code - Code of Practice - Operations and Maintenance
ZS 387 Part 1	Electricity Supply - Power Quality and Reliability - Overview of Implementation and Minimum Standards
ZS 691	Safety in AC Substation Earthing
ZS 692	Substation Fire Protection
IEC 60038	IEC Standard Voltages

3 DEFINITIONS

For the purpose of this Standard the following definitions and those given in ZS 387–1 shall apply.

3.1 **Apparatus**: any device installed or that forms part of a system for generation, transmission or distribution of electricity.

3.2 **Authorised person**: means a Competent person possessing technical knowledge and appointed in writing by an enterprise or consumer of electricity to carry out specific duties or work on the enterprises' or consumers' own electrical system or apparatus.

3.3 **Barricade:** means the physical limits in areas with energised or moving parts where it is safe to work as detailed in the relevant safety documents issued by an Authorised person.

3.4 **Competent person:** means any person who in relation to any duty or function has had adequate training and experience so as to enable him to perform such duty or function without avoidable danger to himself, other persons, animals, equipment, infrastructure and the environment.

3.5 **Danger:** a risk of loss of life, bodily injury, or damage to health from shock, burn or other cause arising from generation, transmission, distribution or use of electric energy.

3.6 **Dead:** means at or about earth potential or zero voltage and not connected to a live conductor or live part of an electrical system.

3.7 **Earthed:** means connected to the general mass of earth in such a manner as to ensure at all times an immediate and efficient discharge of electrical energy without danger.

3.8 **Effective earth/ effectively earthed:** means bonded to an effectively earthed neutral conductor or to an earthing system designed to limit the likelihood of hazards to persons and having resistances to earth low enough to permit prompt operation of circuit protective devices.

3.9 **Effectively earthed neutral conductor:** means a neutral conductor of a multi-earthed system that is intentionally connected to the source transformer neutral directly or through an impedance to limit phase-to-earth fault current. The neutral conductor shall be of sufficient size to carry the available fault current and permit prompt operation of circuit protective devices.

3.10 **Electrical work:** means work in or on an electrical installation such as testing, measurement, repairing, replacing, modifying, extending, erection and inspection.

3.11 **Electrical installation:** means an assembly of associated electrical equipment supplied from a common origin to fulfil a specific purpose and having certain coordinated characteristics.

3.12 **Electrical supply station:** Any building, room, or separate space within which electrical supply equipment is located and the interior of which is accessible, as a rule, only to authorised personnel. This includes generating stations and substations, including their associated generator, storage battery, transformer, and switchgear rooms or enclosures, but does not include facilities such as pad-mounted equipment and installations in manholes and vaults.

3.13 **Electrical systems:** means a system in which all the conductors and apparatus are electrically connected to a common source of electromotive force.

3.14 **Energised:** means live and encompasses any motive force used to drive equipment.

3.15 **Enterprise (licensee):** A body, licensed by the ERB for generation, transmission, distribution and supply of electricity.

3.16 **Equipment:** A general term including fittings, devices, appliances, fixtures, apparatus, and similar terms used as part of or in connection with an electrical supply system.

3.17 **Extra high voltage (EHV):** The set of nominal voltage levels used in power systems in the range U_n >220kV.

NOTE: The definitions of voltage levels of LV, MV, HV and EHV have been defined without any relationship to distribution and transmission voltage.

3.18 **Generating station:** A plant wherein electric energy is produced by conversion from some other form of energy (for example, hydro, chemical, nuclear, solar, mechanical, or hydraulic) by means of suitable

apparatus. This includes all generating station auxiliaries and other associated equipment required for the operation of the plant. Not included are stations producing power exclusively for use with communications systems.

3.19 **High voltage (HV):** The set of nominal voltage levels used in power systems in the range 33 kV < U_n ≤ 220kV.

3.20 **Live:** means electrically connected to a source of potential difference, or electrically charged so as to have a potential significantly different from that of earth in the vicinity.

3.21 **Live area:** means any well-defined and enclosed area within generating station, switching stations or substation containing exposed live conductors.

3.22 **Live working:** means all work in which a person makes contact with live parts or reaches into live working zone with either parts of his or her body, or with tools, equipment or devices being handled.

3.23 **Live working zone:** means a space round live parts within which the insulation level to prevent electrical danger is not assured when encroaching it without protective measures.

3.24 **Lock-out box:** means a box at a generating station, switching station or substation which is used for depositing keys for locks on an equipment which has been taken out of service and is under Permit-To-Work or Sanction-For-Test. The keys deposited in this box are those related only to isolation points on the equipment that has been taken out of service.

3.25 **Low voltage (LV):** The set of nominal voltage levels that are used for the distribution of electricity and whose upper limit is generally accepted to be an a.c. voltage of 1 000 V (or a d.c. voltage of 1500 V).

3.26 **Medium voltage (MV):** The set of nominal voltage levels that lie above low voltage and below high voltage in the range 1 kV ≤ U_n ≤ 33 kV.

3.27 **Non-electrical work:** means work on or to an electrical installation such as mechanical maintenance work, construction, excavation, cleaning, painting, etc. which is not electrical work.

3.28 **Permit holder:** means a Competent person who has been issued with a permit to work or sanction for test or any other relevant safety document.

3.29 **Permit-to-work:** means a written declaration on an approved form and signed by an Authorised person issued to a person in charge of work stating the apparatus upon which it is safe to work and the work to be carried out.

3.30 **Safety document:** means a written form that outlines the necessary precautions, guidelines and rules to ensure safe work practices when working on electrical systems, equipment or installations.

3.31 **Safety notice:** means a notice suitably inscribed and securely displayed and conveying a warning against interference.

3.32 **Sanction-for-test:** means a written declaration on an approved form and signed by an Authorised person issued to a person in charge of testing apparatus for the purpose of making known exactly what apparatus is to be tested and the condition in which the test is to be carried out.

3.33 **Shielding:** means any permanent or temporary safety device that ensures that a person does not enter the live working zone. Shielding may consist of a screen barrier, enclosed or insulated cover.

3.34 **Substation:** means an enclosed assemblage of equipment, e.g. switches, circuit breakers, buses and transformers, under the control of authorised persons, through which electric energy is passed for the purpose of switching or modifying its characteristics.

4 GENERAL SAFETY RULES

4.1 General

(a) All electrical systems and equipment shall be designed, constructed, installed and commissioned to meet the requirements of these rules.

(b) The enterprise, consumer, authorised contractors, or other entities as applicable, performing design, construction, installation or commissioning tasks for electrical systems or equipment covered by this code shall be responsible for meeting applicable requirements.

(c) For all particulars not specified in these rules, construction, installation and commissioning should be done in accordance with accepted good practice for the given local conditions known at the time by those responsible for the construction, installation or commissioning of the electrical systems and equipment.

4.2 Application

(a) The rules shall apply to all new installations and extensions, except that they may be waived or modified by the relevant government agency. When so waived or modified, safety shall be provided in other ways.

NOTE: Alternative working methods such as the use of barricades, guards or other electrical protective equipment, may be implemented along with appropriate alternative working clearances as a means of providing safety when working near live conductors.

(b) Types of construction and methods of installation and commissioning other than those specified in the rules may be used experimentally to obtain information with prior written permission from the relevant government agency. Requirements for obtaining permission for experimental purposes shall include provision of: qualified supervision, equivalent safety measures and timely notification to all affected users on joint-use facilities.

(c) Existing installations, including maintenance replacements that currently comply with prior editions of this code need to be modified to comply with these rules for safety reasons except where a waiver is granted by the relevant government agency.

(d) In case of emergencies, suitable emergency procedures shall apply.

(e) The strength of material and construction for emergency installations shall be not less than required for Grade N construction. Grade N construction has the following characteristics:

- Lightest loading characteristics;
- Lowest strength;
- Smallest safety factors;
- Typically used for communication purposes only;
- Has the lowest grade for conductors; and
- Has the lowest environmental requirements.

(f) Emergency installations shall be removed, replaced or relocated, as desired, as soon as is practicable.

(g) When an installation is for temporary service, or where facilities are temporarily relocated or reconfigured to facilitate other work, the resulting installation shall meet the requirements for non-temporary installation. Additionally, for overhead installations, the strength of material and construction shall be not less than that required for Grade N construction.

(h) Employers/owners shall provide adequate safety equipment and training required for construction, installation and commissioning of electrical systems.

5 CONSTRUCTION

5.1 General requirements for construction

(a) The enterprise's facilities shall:

i) be sufficient in size and rating to perform the intended functions,
ii) be designed, constructed, installed, protected where necessary and of such quality to prevent danger, and
iii) be specially designed and constructed or additionally protected where exposed to:

1. the weather;
2. wet conditions;
3. vermin;
4. corrosion;
5. flammable surroundings;
6. dust; or
7. explosive atmosphere.

(b) Conductors and live parts, except as otherwise provided for in 5.5 or 5.6, shall:

i) be fully insulated and mechanically protected where necessary to prevent danger; or
ii) be so placed and safeguarded as to prevent danger.

(c) Conductors and live parts, unless completely surrounded by earthed metal, shall have the minimum section clearances set out in clause 4.5 of ZS 418 Part 2 or shall be so guarded by a protective barrier as to prevent inadvertent touching or dangerous approach by a person standing on any floor-level, walkway, stairway or working platform.

5.2 Electrical supply stations

5.2.1 General requirements

5.2.1.1 Enclosure of equipment

(a) Types of enclosures

i) Rooms and spaces in which electrical supply conductors or equipment are installed shall be so arranged with barriers such as fences, screens, partitions, or walls to form an enclosure as to prevent unauthorised access.
ii) Entrances not under observation of an authorised person shall be kept locked.
iii) An installed barrier shall meet any one of the following:

1. Fencing material, not less than 2.1 m in height;
2. A combination of 1.8 m or more of fencing material and an extension utilising three or more strands of barbed wire to achieve an overall height of the fence of not less than 2.1 m; or
3. Other types of construction, not less than 2.1 m, that present equivalent barriers to prevent climbing or unauthorised entry.

(b) Safety signs

i) A safety sign shall be displayed on or beside the door or gate at each entrance.
ii) For fenced or walled electrical supply stations without roofs, a safety sign shall be displayed on each exterior side of the fenced or wall enclosure.

iii) Where the station is entirely enclosed by walls and roof, a safety sign is required only at ground level entrances.
iv) Where entrance is gained through sequential doors, the safety sign should be located at the inner door position. (For types of safety signs refer to ZS 418 Part 2 clause 4.2.2).

(c) Metal fences

i) Metal fences or other metallic barriers, when used to enclose electric supply stations having energised electrical conductors or equipment, shall be effectively earthed in accordance with ZS 691.
ii) No fence or similar structure shall be allowed to be connected to or located within 1.8 m of an electrical supply station fence without the consent of the substation owner.

(d) Safety clearance zone

Fences or walls, when installed as barriers for unauthorised persons, shall be located such that exposed live parts are outside the safety clearance zone depending on the type of barrier, as follows:

i) A metal chain-link fence or equivalent barrier, as illustrated in Figure 5-1, shall have an R-value equal to or greater than that specified in Table 5-1; and
ii) Where an impenetrable barrier is used, such as a fence, partition, or wall with no openings through which sticks or other objects can be inserted, the safety zone clearance calculation may be modified to account for the protection offered by the barrier. The sum of the height of the impenetrable barrier (H) and the distance from that point to the closest energised part (R1) must be greater than or equal to the sum of the dimension R and 1.5 m.

$R1 + H \geq R + 1.5\ m$

where

H = Height of impenetrable barrier
R1 = Distance between point at height H and the closest energised part
R = Dimension from Table 5-1

It is acceptable to have a barrier comprised of both penetrable and impenetrable portions. If there are openings in the barrier below the impenetrable portions, the clearance from the lowest impenetrable point to the closest energised part shall be not less than the dimension R from Table 5-1.

Dimension R1 as illustrated in Figure 5-2 is a variable dimension, which is dependent upon the values of R and H.

NOTE : The safety clearance zone requirement is not applicable to internal fences within an electrical supply station perimeter.

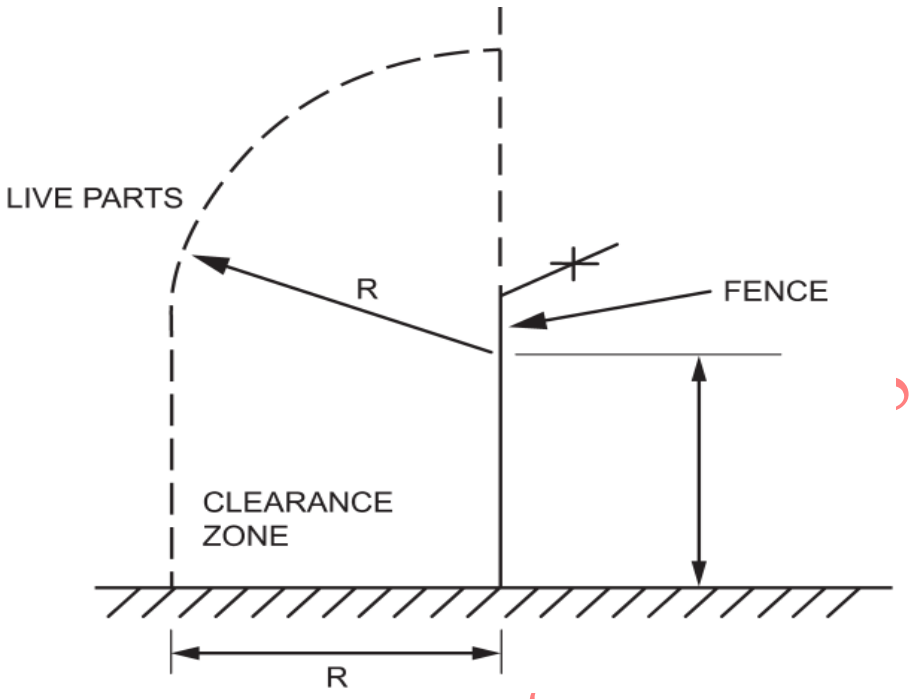

Figure 5-1: Safety clearance to electrical supply station fences
[Source: IEEE National Electrical Safety Code - 2023 (Figure 110-1)]

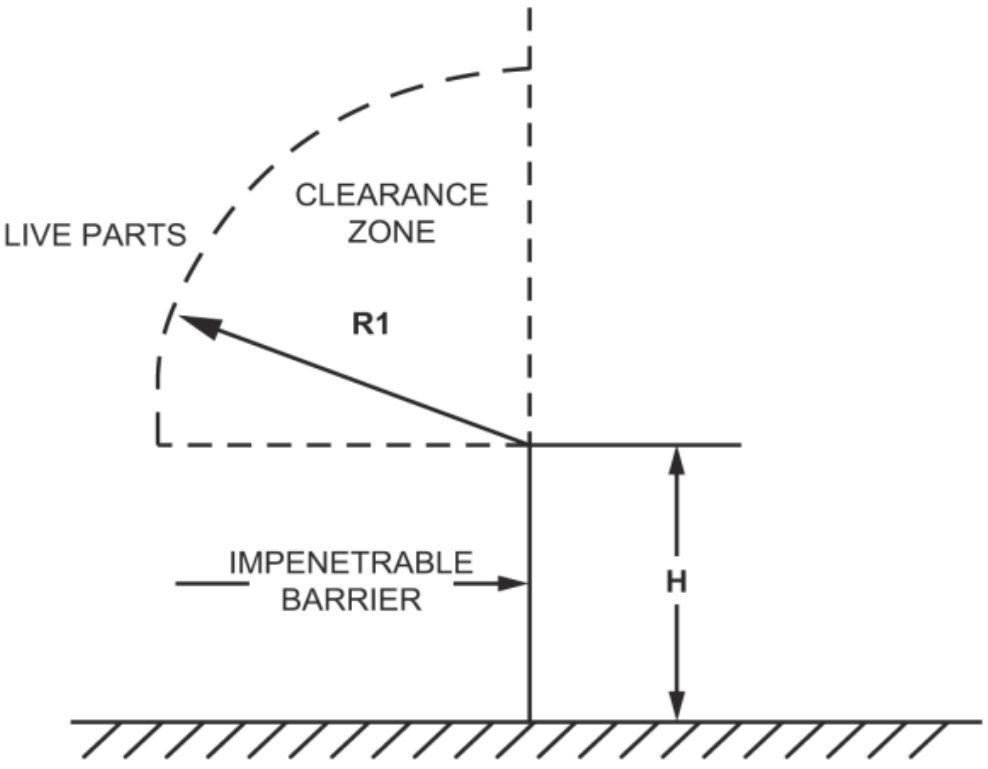

Figure 5-2: Safety clearance to electrical supply station impenetrable fence
[Source: IEEE National Electrical Safety Code - 2023 (Figure 110-2)]

Table 5-1: Values for use with Figure 5-1

Rated voltage	Dimension 'R' (m)
Up to 11 kV	2.6
Exceeding 11 kV but not exceeding 17.5 kV	2.8
Exceeding 17.5 kV but not exceeding 33 kV	2.9
Exceeding 33 kV but not exceeding 66 kV	3.2
Exceeding 66 kV but not exceeding 88 kV	3.4
Exceeding 88 kV but not exceeding 220 kV	4.6
Exceeding 220 kV but not exceeding 330 kV	5.1

5.2.1.2 Indoor substations

All rooms and spaces in which electrical supply equipment is installed shall comply with the following requirements:

(a) The construction materials used shall be non-combustible as far as is practicable;

(b) The rooms and spaces shall be free from combustible materials, dust, and fumes and shall not be used for manufacturing or for storage, except for minor parts essential to the maintenance of the installed equipment;

(c) There shall be sufficient ventilation to maintain operating temperatures within ratings, arranged to minimise accumulation of airborne contaminants under any operating conditions;

(d) The rooms and spaces shall not be exposed to moisture or wet weather conditions and should be kept dry; and

(e) Equipment installed in wet tunnels, subways, or other moist or high humidity locations, shall be suitably designed to withstand the prevailing atmospheric conditions.

5.2.1.3 Below ground level substation

A below ground level substation shall:

(a) have adequate means of access by a door or trapdoor with a staircase or ladder securely fixed and so placed that no energised part of a system or conductor shall be within reach of a person thereon; or
(b) where a person is to be regularly employed therein and energised equipment is present, have the access referred to in (a) by door and staircase only.

5.2.1.4 Outdoor substation

Any part of the enterprise's facilities for the transformation, control and regulation or switching of electricity in the open air shall, except as otherwise provided for in 5.4 and 5.5:

(a) be completely enclosed in a metal casing connected with earth at all points from the ground; or
(b) be mounted on the supports meeting the prescribed safe clearance heights; or
(c) be enclosed by a fence not less than 2.1 m in height fitted with a suitable anti-climbing device for the purpose of preventing access not authorised by enterprise.

5.2.1.5 Electrical equipment and supporting structures

All stationary electrical equipment and supporting structures shall withstand the anticipated conditions of service. Consideration shall be given to the fact that certain heavy equipment, such as transformers, can be secured in place by their weight. However, equipment that generates dynamic forces during operation may require appropriate additional measures.

5.2.2 Illumination

5.2.2.1 Under normal conditions

Every working place shall have means for adequate artificial illumination. Illumination levels not less than those listed in Table 5-2 are recommended for safety to be maintained on the task.

Table 5-2: Illumination levels

Location	foot candles	lux
Generating station (interior)		
Highly critical areas occupied most of the time[1]	25	270
Areas occupied most of the time[2]	15	160
Critical areas occupied infrequently[3]	10	110
Areas occupied infrequently[4]	5	55
Generating station (exterior)		
Building pedestrian main entrance	10	110
Critical areas[5]	5	55
Areas occupied occasionally by pedestrians[6]	2	22
Areas occupied occasionally by vehicles[7]	1	11
Areas occupied infrequently[8]	0.5	5.5
Remote areas[9]	0.2	2.2
Substation		
Control building exterior	5	55
General exterior horizontal and equipment vertical	2	22
Remote areas [10]	0.2	2.2

5.2.2.2 Emergency lighting

(a) A separate emergency source of illumination with automatic initiation, from an independent generator, storage battery, or other suitable source, shall be provided in every station, where this is practical.

(b) Where practicable, emergency lighting shall be provided in exit paths from all areas of stations. Consideration must be given to the type of service to be rendered, whether of short time or long duration. The minimum duration shall be 30 minutes. It is recommended that emergency circuit wiring shall be kept independent of all other wiring and equipment.

[1] Such as: Chemical laboratory, large and centralised control room 1.7 m above floor, section of duplex facing away from operator, bench boards (horizontal level), dispatch boards - horizontal plane (desk level), dispatch boards - vertical face of board 1.2 m above floor, facing operator, - system load dispatch room.

[2] Such as: Ordinary control room 1.7 m above floor, secondary dispatch room, turbine room.

[3] Such as: Auxiliaries, battery areas, boiler feed pumps, tanks, compressors, gage area, burner platforms, hydrogen and carbon dioxide manifold area, screen house, power switchgear, communications equipment room, turbine bay sub-basement, visitors' gallery, water treating area.

[4] Such as: Air-conditioning equipment, air preheater and fan floor, ash sluicing, boiler platforms, cable room, circulator, or pump bay, coal conveyor, crusher, feeder, scale area, pulveriser, fan area, transfer tower, condensers, de-aerator floor, evaporator floor, heater floors, area inside duplex switchboards, rear of all switchboard panels (vertical), precipitators, soot or slag blower platform, steam headers and throttles, piping tunnels or galleries.

[5] Such as: Coal unloading dock (loading or unloading zone), coal unloading car dumper, gate house conveyor entrance, fuel-oil delivery headers, platforms - boiler, turbine deck.

[6] Such as: Catwalks, coal unloading tipple, conveyors, secondary building entrances.

[7] Such as: Oil storage tanks, roadway between or along buildings.

[8] Such as: Coal unloading barge storage area, roadway not bordered by buildings.

[9] Such as: Cinder dumps, fence, open yard.

[10] Such as: Fence, open yard.

5.2.2.3 Fixtures

(a) Arrangements for permanent light fittings and socket outlets shall be such that extensions cables need not be brought into dangerous proximity to energised or moving parts.

(b) All lighting shall be controlled and serviced from safely accessible locations.

5.2.2.4 Attachment plugs and socket outlets for general use

(a) Socket outlets on three-wire single phase, ac branch circuits shall be of the earthed type.

(b) Socket outlets connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that plugs used on such circuits are not interchangeable.

5.2.2.5 Socket outlets in damp or wet locations

All ac socket outlets shall either be provided with Residual Current Device (RCD) protection, or be on an earthed circuit that is tested at such intervals as experience has shown to be necessary or be applied in conjunction with a RCD device between the socket outlet and the load.

5.2.3 Floors, floor openings, passageways, and stairs

5.2.3.1 Floors

Floors shall have even surfaces and afford secure footing. Slippery floors or stairs shall be provided with anti-slip covering.

5.2.3.2 Passageways

Passageways, including stairways, shall be unobstructed and shall, where practicable, provide at least 2.1 m head room. Where the preceding requirements are not practicable, the obstructions shall be painted, marked, or indicated by safety signs, and the area properly lit.

5.2.3.3 Railings

All floor openings without gratings or other adequate cover and raised platforms and walkways in excess of 300 mm in height shall be provided with railings. Opening in railings for units such as fixed ladders, cranes, and the like shall be provided with adequate guards such as grates, chains or sliding pipe sections.

5.2.3.4 Stair guards

All stairways consisting of four or more risers shall be provided with handrails.

5.2.3.5 Top rails

All top rails shall be kept unobstructed for a distance of 75 mm in all directions except from below at supports.

5.2.4 Exits

5.2.4.1 Clear exits

Each room or space and each working space around equipment shall have a means of exit, which shall be kept clear of all obstructions.

5.2.4.2 Double exits

If the plan of the room or space and the character and arrangement of equipment are such that an accident would likely close or make inaccessible a single exit, a second exit shall be provided.

5.2.4.3 Exit doors

Exit doors shall swing out and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

NOTE: This does not apply to exit doors in buildings and rooms containing low-voltage, non - explosive equipment, and to gates in fences for outdoor equipment installations.

5.2.5 Fire protection equipment

(a) Fire protection equipment approved for the intended use shall be conveniently located and conspicuously marked.

(b) The minimum requirements for substation fire protection which include the rules for the design, selection, erection, inspection and testing shall be in accordance with ZS 692.

5.2.6 Storage batteries

5.2.6.1 General

The provisions of this section are intended to apply to all stationary installations of storage batteries.

(a) Working space

i) Sufficient space shall be provided around batteries for safe inspection, maintenance, testing, and replacement.
ii) Sufficient space shall be left above the batteries to allow for the safe operation of lifting equipment where applicable, addition of water, or taking measurements.

(b) Enclosure

Storage batteries shall be located within a protective enclosure of area accessible only to competent persons. A protective enclosure can be a battery room, control building, or a case, cage, or fence that will protect the contained equipment and limit the likelihood of inadvertent contact with energised parts.

(c) Ventilation

i) The battery area shall be ventilated, either by a natural or powered ventilation system to maintain levels of combustible gases below an explosive mixture where batteries are subject to producing such gases.
ii) Failure of a continuously operated or automatically controlled powered ventilation system required by design to limit gas accumulation to less than an explosive mixture shall be annunciated.

(d) Racks

i) Racks refer to frames designed to support cells or trays. Racks shall be firmly anchored, preferably to the floor. Anchoring to both walls and floors is not recommended.
ii) Racks made of metal shall be effectively earthed.

(e) Floor protection

i) Floor areas under a battery that contains corrosive liquids shall be of corrosion-resistant material, protected with corrosion-resistant paint, or otherwise protected.
ii) Provision shall be made to contain spilled electrolyte.

(f) Illumination

i) Lighting fixtures for the illumination of battery areas shall be protected from physical damage by guards or isolation.
ii) Socket outlets and lighting switches, where there is the potential for hazardous combustible gas concentrations, shall be located outside of battery areas.

(g) Personal protective equipment (PPE)

Where installed batteries contain electrolyte, proper eye, face, hand and skin protection shall be provided in the battery area appropriate to the electrolyte hazard during battery maintenance and installation and shall consist of the following:

i) Goggles or face shield;
ii) Electrolyte-resistant gloves;
iii) Protective aprons and overshoes; and
iv) Portable or stationary water facilities or neutralising agent for rinsing eyes and skin.

NOTE: The PPE shall also be provided in areas containing batteries denoted as sealed, gel, or maintenance-free batteries (e.g., VRLA batteries).

(h) Safety signs

Safety signs inside and outside of a battery room or in the vicinity of a battery area, prohibiting smoking, sparks, or flame shall be displayed where batteries are subject to producing combustible gases.

(i) Battery charging system

i) The battery charger shall be located in an area designated for that purpose.
ii) The charger shall be made of non-combustible material.
iii) The battery charger shall be monitored and operated in accordance with the battery manufacturer's recommendations.

5.2.6.2 Switchgear and plant batteries

Switchgear and plant batteries are those batteries used to supply dc energy in the control and operation of generating station and substation safety, switching, protective devices, and systems. Batteries used in this application shall meet the following requirements:

(a) Switchgear and plant batteries shall not be used for grid storage applications.

(b) Battery systems shall be sized to provide the necessary dc energy with a specified duration and rate to allow for remediation of a faulted or loss of dc charging system

5.2.6.3 Grid storage batteries

Grid storage batteries are those batteries that discharge their energy into a utility's electric power supply grid. Batteries used in this application shall meet the following requirements:

(a) Grid storage batteries shall not be used for switchgear and plant battery applications.

(b) Battery installations that pose a fire hazard shall provide protective measures to prevent a battery fire from damaging adjacent structures and equipment.

(c) Battery installations containing hazardous liquids shall have spill containment.

(d) Battery installations shall have signage regarding fire, toxic chemicals, and other hazards prominently displayed in the battery area.

NOTE: Grid storage battery sites that allow first responders to address hazards should consider having a remote monitoring station to annunciate hazardous conditions and to provide information or controls needed to remediate such condition.

5.3 Photovoltaic generating stations

The provisions of this section apply to photovoltaic (PV) generating stations that are under the exclusive control of utilities and are not mounted on occupied buildings.

5.3.1 Location

Access to PV generating stations shall be restricted to authorised personnel only, by fencing or other adequate means of controlled access.

5.3.2 Earthing configurations

(a) PV array dc circuits shall be permitted to be unearthed or to employ functional earthed PV dc conductors. Protective earths within the dc system shall comply with requirements of ZS 691.

(b) AC circuits in a PV generating station shall be earthed in accordance with the methods specified in ZS 691 and clause 5.6.

5.3.3 Vegetation management

Vegetation management shall be performed around the PV generating station.

5.3.4 DC conductors

(a) Unearthed and functional earthed PV dc conductors shall be insulated unless otherwise guarded.

(b) Cables secured to racking or tracking structures shall be protected from physical damage.

5.4 Cables

5.4.1 General

(a) A cable should be capable of withstanding tests applied in accordance with an applicable standard issued by Zambia Bureau of Standards (ZABS) and other internationally recognised organisations such as International Electro-technical Commission (IEC), American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM) or National Electrical Manufacturers Association (NEMA). The selection of the cable for use in accordance with this standard should be such that:

i) The design and construction of conductors, insulation, sheath, jacket, and shielding shall include consideration of mechanical, thermal, environmental, and electrical stresses that are expected during installation and operation;
ii) A cable shall be designed and manufactured to retain specified dimensions and structural integrity during manufacture, reeling, storage, handling and installation;
iii) A cable shall be designed and constructed in such a manner that each component is protected from harmful effects of other components; and
iv) The conductor, insulation, and shielding shall be designed to withstand the effects of the expected magnitude and duration of fault current, except in the immediate vicinity of the fault.

(b) A cable shall be fully insulated for the normal operating voltage and shall be of a type and construction and shall be laid or installed in a manner suited to its particular environment and having regard to:

i) the provisions of 5.1(a);
ii) the normal usage of the ground in which any part of it is to be laid; and
iii) foreseeable risk of damage to the cable and danger to persons, infrastructure and to other electrical services, water, gas, sewerage and telegraph services, railways and constructional works at or below ground-level.

(c) A component used with a cable shall be of a type and construction and shall be laid or installed in a manner suited to that cable and having regard to the following:

i) 5.4.1 (b) above;
ii) where a joint or connection is necessary, the electrical joint or connection shall be designed, constructed, installed and protected in such a manner that:

1. electrical conductivity is maintained satisfactorily;
2. its insulation, where insulation is necessary, is suitable for the normal operating voltage; and
3. its mechanical strength is suited to its location and environment.

5.4.2 Identification and colour coding of cables

Colour is one of the methods used to identify the conductors of a wiring system where it is possible to colour the insulation. Where it is not, numbers, letters or other industry recognised and accepted identification features should be used. The requirements for identification of fixed wiring shall be as shown in Table 5-3:

Table 5-3: Cable identification

Cable type (Insulation)	**Single phase**	**Three-phase**
Rubber/PVC/EPR/XLPE	Protective – Green/Yellow Neutral – Black Phase – Red	Neutral – Black Blue Yellow/white } Phase Red
Mineral	Neutral – Black Sleeve/Disc Phase – Red Sleeve/Disc	Neutral – Black Sleeve Blue Yellow/White } Phase Red (Sleeves/Discs)
Paper Or EPR Or XLPE	Neutral - Black or **- 0 numbered Tag** Phase - Red or - 1 numbered tag	Neutral – 0 (Black) 1 (Red) 2 (Yellow) 3 (Blue) } Phase 4 (Special Conductor)
Flexible	**Neutral – Blue,** Protective – Green/Yellow	Phase – Brown
Aerial Bundle Conductor (ABC)	Neutral – Smooth insulation jacket Phase - Continuous ridge on its insulation jacket throughout its length	Neutral – Continuous ridge on its insulation jacket throughout its length 1 (A or U) 2 (B or V) 3 (C or W) } Phase
DC Cables	Negative – Black, negative mark (-ve) Positive – Red, positive mark (+ve)	N/A
Blasting Cables	Twin twisted flex - One yellow sheath and one green sheath Multi-core sheath - Coloured yellow throughout its length	N/A

5.4.3 Sheaths and jackets

Sheaths, jackets, or both shall be provided when necessary to protect the insulation or shielding from moisture or other adverse environmental conditions.

5.4.4 Shielding and material

(a) Conductor shielding should, and insulation shielding shall, be provided as specified by an applicable document issued by ZABS and other internationally recognised standardisation organisations.

NOTE: Shielding is not required for short jumpers that do not contact an earthed surface within enclosures or vaults, provided the jumpers are guarded or isolated.

(b) Insulation shielding may be sectionalised provided that each section is effectively earthed.
(c) The shielding system may consist of semiconducting materials, non-magnetic metal, or both. The shielding adjacent to the insulation shall be designed to remain in intimate contact with the insulation under all operating conditions.
(d) Shielding material shall either be designed to resist excessive corrosion under the expected operating conditions or shall be protected.

5.4.5 Cable joints and accessories

(a) Cable accessories and joints shall be designed to withstand the mechanical, thermal, environmental, and electrical stresses expected during operation.
(b) Cable accessories and joints shall be designed and constructed in such a manner that each component of the cable and joint is protected from harmful effects of the other components.
(c) Cable accessories and joints shall be designed and constructed to maintain the structural integrity of the cables to which they are applied and to withstand the magnitude and duration of the fault current expected during operation, except in the immediate vicinity of the fault.
(d) For insulating joints, 5.4.4 (b) applies.

5.4.6 Blasting cables

Every blasting cable shall be readily identified by colour as specified in Table 5-3 and shall not be used for any other purpose than blasting.

5.4.7 Cable in underground structures (include cable for cable-to-cable supply and communications)

(a) On systems operating above 1 kV to earth, the design of the conductors or cables installed in non-metallic conduit should consider the need for an effectively earthed shield, a sheath, or both.
(b) Bending the supply cable during handling, installation, and operation shall be controlled to avoid damage.

NOTE: Manufacturers' recommendations may be used as a guide.

(c) Pulling tensions and sidewall pressures on the supply cable should be limited to avoid damage.
(d) Ducts should be cleaned of foreign material that could damage the supply cable during the pulling operations.
(e) Cable lubricants shall not be detrimental to cable or conduit systems.
(f) On slopes or vertical runs, consideration should be given to restraining cables to limit the likelihood of downhill movement.
(g) Supply, control, and communication cables shall not be installed in the same duct unless the cables are maintained or operated by the same utility.
(h) Trunking and ducting must be installed so as to ensure that they will not be damaged by water or by corrosion. Trunking must be supported sufficiently to avoid failure.
(i) No single- core flexible cable shall be used for supplying portable or mobile apparatus other than trolley-wire locomotives or welding electrode holders; each conductor in a flexible cable shall be covered with insulating material and such conductor and insulating material shall be adequately protected from damage.
(j) A metallic covering provided to protect a flexible cable from damage shall not be used as the sole earthing conductor in respect of such cable or any apparatus connected thereto unless such cable is of an approved specification.
(k) No halogen, reduced smoke emission and reduced propagation (NHLSFR) insulated cables shall be used for underground installations.

NOTE: The NHLSFR insulated cables can be used in public spaces or areas without limited ventilation.

5.4.8 Cables in manholes and vaults

5.4.8.1 Supports

(a) Cable supports shall be designed to withstand both live and static loading and should be compatible with the environment.
(b) Supports shall be provided to maintain specified clearance between cables.
(c) Horizontal runs of supply cables shall be supported at least 75 mm above the floor, or be suitably protected.

NOTE: This rule does not apply to earthing or bonding conductors.

(d) The installation should allow cable movement without destructive concentration of stresses. The cable should remain on supports during operation.

NOTE: Special protection may be necessary at the duct entrance.

5.4.8.2 Clearance

(a) Adequate working space shall be provided.
(b) Between supply and communications facilities (cable, equipment, or both):

i) Where cable, equipment, or both are to be installed in a joint-use manhole or vault, it shall be done only with the concurrence of all parties concerned.
ii) Supply and communication cables should be racked from separate walls. Crossings should be avoided.
iii) Where supply and communication cables must be racked from the same wall, the supply cables should be racked below the communication cables.
iv) Supply and communications facilities shall be installed to permit access to either, without moving the other.
v) Clearances shall not be less than those specified in Table 5-4.

Table 5-4: Clearance between supply and communications facilities in joint-use manholes and vaults

Phase-to-phase supply voltage (V)	Surface-to-surface (mm)
0 to 11 000	150
11 001 to 66 000	230
66 001 to 132 000	300
132 001 and above	600

NOTE 1: These clearances do not apply to earthing conductors.

NOTE 2: These clearances may be reduced by mutual agreement between the parties concerned when suitable barriers or guards are installed.

5.4.8.3 Identification

(a) General

i) Cables shall be permanently identified by tags or otherwise at each manhole or other access opening of the conduit system.
ii) All identification shall be of a corrosion-resistant material suitable for the environment.
iii) All identification shall be of such quality and located so as to be readable with auxiliary lighting.

(b) Joint-use manholes

Where cables in a manhole are maintained or operated by different utilities or are of supply and communication usage, they shall be permanently marked as to company or type of use, and voltage level.

5.4.8.4 Earthing and bonding

(a) Cable and joints with bare metallic shields, sheaths, or concentric neutrals shall be effectively earthed.
(b) Cable sheaths or shields that are connected to earth at a manhole shall be bonded or connected to a common earth.
(c) Bonding and earthing leads shall be of a corrosion-resistant material suitable for the environment or suitably protected.

NOTE: Earthing and bonding to be done in accordance with ZS 691.

5.4.8.5 Fireproofing

Fireproofing may be provided in accordance with each utility's normal service reliability practice for protection from external fire.

5.4.8.6 Communication cables containing special supply circuits

(a) Special circuits operating at voltages in excess of 400 V to earth and used for supplying power solely to communications equipment may be included in communication cables under the following conditions:

i) Such cables shall have a conductive sheath or shield that shall be effectively earthed and each such circuit shall be carried on conductors that are individually enclosed with an effectively earthed shield;
ii) All circuits in such cables shall be owned or operated by one party and shall be maintained only by competent persons;
iii) Supply circuits included in such cables shall be terminated at points accessible only to competent persons;
iv) Communication circuits brought out of such cables, if they do not terminate in a repeater station or terminal office, shall be protected or arranged so that in the event of a failure within the cable, the voltage on the communication circuit will not exceed 400 V to earth;
v) Terminal apparatus for the power supply shall be so arranged that live parts are inaccessible when such supply circuits are energised.
vi) Such cables shall be identified, and the identification shall meet the pertinent requirement of 5.4.7 (c).

NOTE: These requirements do not apply to supply circuits of 550 V or less that carry power not in excess of 3200 W.

5.4.9 Direct buried cable

5.4.9.1 General requirements

(a) Cables operating above 1000 V to earth shall have a continuous metallic shield, sheath, or concentric neutral that is effectively earthed.

NOTE: At a splice or joint, the current path of the metallic shield, sheath, or neutral shall be made continuous but need not be concentric.

(b) Cables meeting the requirements of 5.4.9.1 (a) of the same supply circuit may be buried with no deliberate separation.
(c) Cables of the same circuit operating below 1000 V to earth and without an effectively earthed shield or sheath shall be placed in close proximity (no intentional separation) to each other.
(d) Communication cables containing special circuits supplying power solely to communications equipment shall comply with the requirements 5.4.8.6 (a) i) through 5.4.8.6 (a) vi).
(e) Bonding should be provided between all above earth metallic power and communications apparatus (pedestals, terminals, apparatus cases, transformer cases, etc) that are separated by a distance of 1.8 m or less.
(f) All direct-buried jacketed supply cable and all direct-buried communication cables shall be legibly marked.

NOTE: The requirements in clause 5.4.9 shall also apply to supply and communication cables installed in a duct that is not part of a metallic conduit system.

5.4.9.2 Location and routing

(a) General

i) Cables should be located so as to be subject to the least disturbance practicable. Cables to be installed parallel to other subsurface structures should not be located directly over or under other subsurface structures, but if this is not practicable, the requirements on separations in 5.4.9.3 should be followed.

ii) Cables should be installed in as straight and direct a line as practicable. Where bends are required, the bending radius shall be sufficiently large to limit the likelihood of damage to the cable being installed.

iii) Cable systems should be routed so as to allow safe access for construction, inspection and maintenance.

iv) The location of structures in the path of the projected cable route shall, as far as practicable, be determined prior to trenching, ploughing or boring operation.

(b) Natural hazards

Routes through unstable soil such as mud, shifting soils, corrosive soils, or other natural hazards should be avoided. If burying is required through areas with natural hazards, the cables shall be constructed and installed in such a manner as to protect them from damage. Such protective measures should be compatible with other installations in the area.

(c) Other conditions

i) Swimming pools

Supply cable shall not be installed within 1.5 m of a swimming pool or its auxiliary equipment. If 1.5 m is not attainable, supplemental mechanical protection shall be provided.

ii) Buildings and other structures

Cable should not be installed directly under building or storage tank foundations. Where a cable must be installed under such a structure, the structure shall be suitably supported to limit the likelihood of transfer of a detrimental load onto the cable.

iii) Railroad tracks

1. The installation of cable longitudinally under the ballast section for railroad tracks should be avoided. Where cable must be installed longitudinally under the ballast section of a railroad, it should be located at a depth of not less than 1.3 m below the top of the rail.

   NOTE 1: Where this is impracticable, or for other reasons, this clearance may be reduced by agreement between the parties concerned.

   NOTE 2: Where unusual conditions exist or where proposed construction would interfere with existing installations, a greater depth than specified above would be required.

2. Where a cable crosses under railroad tracks, the top of the conduit system should be located not less than 900 mm below the top of the rails of a street railway or 1.3 m below the top of the rails of a railroad. Where unusual conditions exist or where proposed construction would interfere with existing installations, a greater depth than specified above may be required.

iv) Highways and streets

The installation of cable longitudinally under travelled surfaces of highways and streets should be avoided. When cable must be installed longitudinally under the roadway, it should be installed in the shoulder or, if this is not practicable, within the limits of one lane of traffic to the extent practicable.

v) Water

Cable or cable in duct installed under water should be routed, installed, or both, so that it will be protected from erosion by tidal action or currents. The cable or cable in duct should not be located where ships normally anchor.

vi) Bridges

Where permitted by the bridge owner, cables may be run in duct attached directly to the bridge. The duct shall be located so as to limit the likelihood of damage by traffic and be located to provide safe access for inspection or maintenance of both the bridge and the duct.

5.4.9.3 Separations from other underground structures

The provisions of these sections will apply to the separation of supply and communication cables or conductors from each other and from other underground structures such as sewers, water lines, gas and other lines that transport flammable material, building foundations and steam lines.

(a) Radial separation

i) The radial separation between direct-buried cable and other underground structures should be not less than 300 mm to permit access to and maintenance of either facility without damage to the other.
ii) Where a cable system is to be installed directly over and parallel to another underground structure (or another underground structure installed directly over and parallel to a cable), it may be done provided all parties are in agreement as to the method. Adequate vertical separation shall be maintained to permit access to and maintenance of either facility without damage to the other cables.

(b) Crossings

i) Where a cable crosses under another underground structure, the structure shall be suitably supported to limit the likelihood of transferring of a detrimental load onto the cable system.
ii) Where a cable crosses over another underground structure, the cable shall be suitably supported to limit the likelihood of transferring a detrimental load onto the structure.
iii) Adequate support may be provided by installing the facilities with sufficient vertical separation.

(c) Steam or cryogenic lines

Cable should be installed with sufficient separation from other underground structures, such as steam or cryogenic lines, to avoid thermal damage to the cable. Where it is not practicable to provide adequate clearance, a suitable thermal barrier shall be placed between the two facilities.

5.5 Overhead lines

This section provides for the practical safeguarding of persons during the design, construction, installation and commissioning of overhead supply and communication lines and their associated equipment.

5.5.1 Conductors

(a) Conductors shall be suitable for the location, use, and voltage. Conductors shall have ampacity that is adequate for the application.
(b) Line conductors and earth conductors shall be of copper, cadmium copper, steel-cored copper, aluminium, steel-cored aluminium, aluminium clad steel, aluminium alloy, copper-clad steel, galvanised steel, stainless steel or any compatible combination of these materials.
(c) Cradle supporting wires and stay-wires shall be of stranded galvanised steel or be of material of not less than equivalent strength and durability.

5.5.2 Supports

(a) A support shall be of wood, metal or reinforced concrete or a combination of these materials and where wood or metal is used in the construction of a support, such wood or metal shall be protected against decay or corrosion as far as is reasonably practicable.
(b) The diameter of a wooden support at a point 1.5 m from the butt shall be not less than 15 cm.
(c) Supports and the foundations thereof shall be constructed and placed having regard to the characteristics of the support height, ground in which they are embedded and to the load which they are to carry.

5.5.3 Insulators

Insulators shall be:

(a) of durable materials;
(b) designed to withstand the mechanical loading and electrical stresses of normal operating conditions; and
(c) suitable to the environment they will operate in.

5.5.4 Minimum heights and clearances

(a) The height above the ground of a line conductor shall be not less than the appropriate height set out in Table 5-5.

Table 5-5: Minimum heights of overhead lines

	Normal operating voltage between line conductors	Height to the lowest conductor (m)
1.	Not exceeding 1000 V, bare type conductor (open-country)	5.1
2.	Not exceeding 1000 V, insulated type conductor (open-country)	5.0
3.	33 000 V, bare or insulated (open-country)	5.3
4.	33 000 V, bare or insulated (other areas)	5.5
5.	66 000 V	5.9
6.	88 000 V	6.3
7.	132 000 V to 220 000 V	6.7
8.	330 000 V	7.2
9.	400 000 V	7.8

(b) A line conductor near a building or other permanently raised position existing at the time of erection of the line shall:

i) if operating at low voltage or medium voltage, be insulated at all places within a distance of 2.3 m from any part of such building or raised position; or
ii) if operating at high voltage, unless completely surrounded and protected by earthed metal, shall have the section clearance or protective barrier referred to in 5.1(c) between it and any part of such building or raised position.

(c) Service lines in the terminal span of a connection between an overhead line and a building or in a span between one building and another building shall be insulated conductors.

(d) The point of attachment of a service line shall:

i) where connected to an overhead line, be at a support except for vertical service connections not exceeding 3.0 m in length;
ii) where connected to a building, be at a terminating device securely fixed to the building.

(e) the height above ground of a line conductor shall be not less than the appropriate height set out in Table 5-5 provided that the height above ground of a low-voltage or medium-voltage insulated line conductor shall be not less than:

i) where a service line is used in the terminal span of a connection between an overhead line and a building or in a span between one building and another building, 3.0 m at any point up to and including the point of attachment to the building where the line does not cross over a road normally accessible to vehicular traffic;
ii) where the line does cross over a road normally accessible to vehicular traffic, 4.3 m.

(f) the height above a road surface of earth conductors, stay-wires and cradles fitted between supports shall be not less than 5.5 m over roads normally accessible to vehicular traffic.

NOTE: The minimum height or clearance required by these regulations shall be maintained under any conditions of loading and temperature likely to occur in the area concerned.

(g) A conductor, other than an earth conductor, leading to or from a transformer or other apparatus at a pole-mounted substation shall, at all points below a height of 3.7 m from the ground, be insulated and, in the case of a high-voltage conductor, shall have earthed metal sheathing or screening.

5.5.5 Overhead lines crossing railway tracks

Where an overhead line crosses a permanent railway track having a gauge of not less than 9.2 cm, the following conditions shall apply:

(a) the height above the rail of an earth conductor, stay-wire or cradle shall be not less than 7.0 m and of a line conductor shall be not less than the appropriate height set out in Table 5-6;
(b) there shall be no joints in the crossing span;
(c) a crossing shall be made at right angles or as near thereto as practicable, provided that where the angle of crossing is less than 70°, such crossing shall be the subject of a special agreement with the authority responsible for the operation of the railway;
(d) the length of span at a crossing shall be as short as is reasonably practicable;
(e) conductors used at a crossing shall be stranded and be not less than 0.2 cm^2 cross-sectional area copper or its equivalent conductivity.

Table 5-6: Minimum heights of overhead lines crossing railway tracks

	Normal operating voltage between line conductors	Minimum height above rail (m)
1.	Not exceeding 33 kV, insulated type conductor	7.0
2.	Not exceeding 33 kV, bare type conductor	7.5
3.	Exceeding 66 kV but not exceeding 88 kV	7.9
4.	Exceeding 88 kV but not exceeding 132 kV	8.5
5.	Exceeding 132 kV but not exceeding 220 kV	8.8
6.	Exceeding 220 kV but not exceeding 330 kV	10.5
7.	400 kV	13.0

5.5.6 Different voltages in proximity

(a) Where a high-voltage overhead line crosses a low-voltage or medium-voltage overhead line or where line conductors forming part of such different systems are erected on the same supports, provision shall be made to guard against the lower voltage system being charged above its normal voltage by the higher voltage system.

(b) Where a pilot circuit is installed and operated as part of an overhead line system, the provisions of (a) above shall apply and such pilot circuit shall be installed and operated with due regard to any dangers which may arise from its use.

5.5.7 Loading conditions and factors of safety

In calculating the strength of the various constituent parts, including supports, of an overhead line, the following basic design conditions shall be assumed:

(a) a minimum temperature of −1 ºC;

(b) the wind pressure acting on the projected area of line conductors and supports not exceeding 12 m in height shall be not less than 56 kg/m^2 and of those exceeding 12 m but not exceeding 36 m in height shall be not less than 71 kg/m^2.

In the case of conductors, earth wires and round, elliptical or hexagonal poles used as supports, the area on which the pressure acts shall be taken as 60 % of the projected area and in the case of lattice or composite structures as one and a half times the projected area of the constituent parts on one side. In the design of spans of over 122 m, the assumed wind load on conductors and earth wires may be reduced to 70 % of the calculated load. In the design of conductor spans, due regard shall be given to the possibility of injurious conductor vibration caused by wind.

(c) A support shall be designed so that the failing load under operating conditions shall be not less than the resultant of simultaneous horizontal and vertical loads calculated in accordance with these provisions, multiplied by the following factors:

i) where the support is of metal, 2.5;
ii) where the support is of concrete, 2.5;
iii) where the support is of wood, 3.5.

(d) The load in a line conductor, earth conductor, insulator, joint or cradle component or an associated fitting under operating conditions shall not exceed 50 % of its ultimate breaking load.

(e) Notwithstanding the provisions of this Standard, the minimum permissible size for a single line conductor shall be such as to have an ultimate breaking load of not less than 363 kg and shall be not less than 6 mm^2 cross sectional area.

5.5.8 Periodic testing and inspecting

(a) Where a protective device is installed to make a line conductor dead, the earthing system of the overhead line with which the system is associated shall be tested on at least one point by the enterprise or competent person:

i) before commissioning such overhead line;
ii) thereafter at intervals of not more than six years; and
iii) repaired if necessary.

(b) The purpose of a test made in terms of (a) shall be to ensure that the leakage resulting from contact of negligible resistance between a line conductor and any metal-work connected with earth is sufficient to operate the protective device.

(c) An overhead line, pole-mounted substation, outdoor substation and support shall be inspected from ground level or above by the enterprise before commissioning and at intervals not exceeding six years after initial date of inspection and repaired if necessary.

(d) The test or inspection made shall be recorded by the person making the test or inspection and such record shall be retained by the enterprise until the next test or inspection is made.

5.5.9 Warning notices

There shall be a safety sign fixed in a prominent position at every pole-mounted substation.

5.5.10 Anti-climbers

In order to prevent as far as is reasonably practicable climbing which has not been authorised by the enterprise, an anti-climbing device shall be fitted:

(a) at every support for a pole-mounted substation;

(b) at every support which has broken surfaces within 3 m of the ground.

5.6 Earthing of electrical supply facilities

This section provides practical methods of earthing, as one of the means of safeguarding employees and the public from injury that may be caused by electrical potential. Additional information can be obtained from ZS 691.

5.6.1 Point of connection of earthing conductor

5.6.1.1 Direct current systems that are to be earthed

(a) 1500 V and below

i) Connection shall be made only at supply stations.
ii) In three wire dc systems, the connection shall be made to the neutral.

(b) Over 1500 V

i) Connection shall be made at both the supply and load stations.
ii) The connection shall be made to the neutral of the system. The earth or earthing electrode may be external to or remotely located from each of the stations. One of the two stations may have its earthing connection made through surge arresters provided the other station neutral is effectively earthed as described above.

NOTE: Where the stations are not geographically separated as in back-to-back converter stations, the neutral of the system should be connected to earth at one point only.

5.6.1.2 Alternating current systems that are to be earthed

(a) 1000 V and below

i) The point of the earthing connection on a star-connected three-phase four-wire system, or on a single-phase three-wire system, shall be the neutral conductor. On other one, two, or three-phase systems with an associated lighting circuit or circuits, the point of earthing connection shall be on the common circuit conductor associated with the lighting circuits.
ii) The point of earthing connection on a three-phase three-wire system, whether derived from a delta-connected or an unearthed star-connected transformer installation not used for lighting, may be any of the circuit conductors, or it may be a separately derived neutral.
iii) The earthing connections shall be made at the source, and at the line side of all service equipment.

(b) 1000 V earthing via neutral resistance

i) The point of earthing connection for a star-connected 3-phase shall be the neutral conductor. Necessary measures shall be taken to limit the current flowing to earth.

NOTE: Methods that could be used here may include earthing resistors and conductors.

ii) For delta-connected 3-phase 3-wire system earthing shall be via suitably erected earthing compensators (or earthing transformers).

5.6.1.3 Separate earthing conductor

If a separate earthing conductor is used as an adjunct to a cable run underground, it shall be connected either directly or through the system neutral to the source transformers, source transformer accessories and cable accessories where these are to be earthed. This earthing conductor shall be located in the same direct burial or duct bank run (or the same duct if this is of magnetic material) as the circuit conductors.

NOTE 1: The earthing conductor for a circuit that is installed in a magnetic duct need not be in the same duct if the duct containing the circuit is bonded to the separate earthing conductor at both ends.

NOTE 2: The earthing conductor in this case should be capable of carrying the full fault current when an earth fault occurs.

5.6.1.4 Messenger and stay wires

(a) Messenger wires

Messenger wires required to be effectively earthed shall be connected to earthing conductors at poles or structures to total not less than the number of earthing locations shown below:

i) Where messenger wires are adequate for system earthing conductors, four connections in each 1.6 km; and

NOTE: Where the terrain (such as river crossings or mountainous areas) being crossed limits the installation of supporting structures every 0.4 km or less, the requirement of made electrodes to total not less than four earths in each 1.6 km of the entire line does not apply for this portion if the messenger is of sufficient size and ampacity for the duty involved. However earthing connections to the messenger shall be made at all structures for this portion of the messenger.

ii) Where messenger wires are not adequate for system earthing conductors, eight connections in each 1.6 km, exclusive of service earths.

(b) Stay wires

Stay wires that are required to be effectively earthed shall be connected to one or more of the following:

i) An effectively earthed metallic supporting structure;
ii) An effective earth on a non-metallic supporting structure; or
iii) An effectively earthed neutral conductor.

(c) Common earthing of messenger and stay wires on the same supporting structure

i) Where messenger and stay wires on the same supporting structure are required to be effectively earthed, they shall be bonded together and effectively earthed by connecting to:

1. One earthing conductor that is effectively earthed at that structure; or to
2. Separate earthing conductors or effectively earthed messengers that are bonded together and earthed at that structure; or to
3. One or more earthed line conductors or effectively earthed messengers that are (a) bonded together at this structure or elsewhere and (b) multi-earthed elsewhere at intervals as specified in 5.6.1.4 (a) and 5.6.1.4 (b) above.

ii) At common crossing structures, messenger and stay wires that are required to be earthed shall be bonded together at that structure and earthed in accordance with 5.6.1.4 (c) i) above.

NOTE: This requirement does not apply to stay wires that are connected to an effectively earthed overhead static wire.

5.6.1.5 Current in earthing conductor

Earth connection points shall be so arranged that under normal circumstances there will be no objectionable flow of current over the earthing conductor.

NOTE: Under normal system conditions an earthing conductor current will be considered objectionable if the electrical or communication system's owner/operator deems such current to be objectionable, or if the presence and/or electrical characteristics of the earthing conductor current is in violation of rules and regulations governing the electrical system, as set forth by the authority having jurisdiction to promulgate such rules.

5.6.1.6 Fences

(a) Conductive electric supply station fences that are required to be effectively earthed shall be designed to limit touch, step, and transferred voltages in accordance with ZS 691 and best industry practices.

(b) The earthing connections of electrical supply station fences shall be made either to the earthing system of the enclosed equipment or to a separate earth.

i) Conductive supply station fences shall be earthed at each side of a gate or other opening.
ii) Conductive supply station fence gates shall be bonded to the earthing conductor, jumper, or fence.
iii) A buried bonding jumper shall be used to bond across a gate or other opening in the supply station fence, unless a non-conducting fence section is used.
iv) If barbed wire strands are used above the supply station fence fabric, the barbed wire strands shall be bonded to the earthing conductor, jumper, or fence.
v) When supply station fence posts are of conducting material, the earthing conductor shall be connected to the fence post or posts, as required, with suitable connecting means.
vi) When supply station fence posts are of non-conducting material, suitable bonding connection shall be made to the fence mesh strands and the barbed wire strands at each earthing conductor point.

6 INSTALLATION

6.1 General requirements for installation

(a) All electric equipment shall be constructed, installed, and maintained so as to safeguard personnel as far as practicable.

(b) New equipment shall be inspected and tested before being placed in service. These tests shall be in accordance with best industry practices.

6.2 Substations

6.2.1 Transformers and regulators

6.2.1.1 Current transformer secondary circuits protection

Secondary circuits, when in a primary voltage area exceeding 1000 V shall, except for short lead lengths at the terminals of the transformer, have the secondary wiring adequately protected by means of earthed conduit or by an earthed metallic covering. Current transformers shall have a provision for shorting the secondary winding.

6.2.1.2 Earthing secondary circuits of instrument transformers

The secondary circuits of instrument transformers shall be effectively earthed where functional requirements permit.

6.2.1.3 Location and arrangement of power transformers and regulators

(a) Outdoor installations

i) Power transformers and regulators shall be so installed that all energised parts are enclosed or guarded so as to limit the likelihood of inadvertent contact, or the energised parts shall be physically isolated. The casing shall be effectively earthed or guarded.
ii) The installation of liquid-filled transformers shall utilise one or more of the following methods to minimise fire hazards. Recognised methods are the use of less flammable liquids, space separation, fire-resistant barriers, automatic extinguishing systems, absorption beds, enclosures, bund walls and line sumps in accordance with ZS 692. The method to be applied shall be according to the degree of the fire hazard.
iii) The amount and characteristics of liquid contained shall be considered in the selection of space separation, fire-resistant barriers, automatic extinguishing systems, absorption beds, enclosures, bund walls and line sumps, that confine the liquid of a ruptured transformer tank, all of which are recognised as safeguards.

(b) Indoor installations

i) Transformers and regulators of 75 kVA and above containing an appreciable amount of flammable liquid and located indoors shall be installed in ventilated rooms or vaults separated from the rest of the building by fire walls. Doorways to the interior of the building shall be equipped with fire doors and shall have means of containing the liquid.

ii) Transformers or regulators of the dry type or containing a non-flammable liquid or gas may be installed in a building. When installed in a building used for other than station purposes, the casing or the enclosure shall be so designed that all energised parts are enclosed in the casing that is effectively earthed. As an alternate, the entire unit may be enclosed so as to limit the likelihood of inadvertent contact by persons with any part of the casing or wiring.

iii) Transformers containing less flammable liquid may be installed in a substation building in such a way as to minimise fire hazards. The amount of liquid contained, the type of electrical protection, and tank venting shall be considered in the selection of space separation from combustible materials or structures, liquid confinement, fire resistant barriers, enclosures, bund walls and line sumps or extinguishing systems.

6.2.1.4 Short circuit protection of power transformers

Power transformers shall be provided with means to automatically disconnect the source of supply of current for a high magnitude short circuit (fault) within the transformers.

The devices for automatically disconnecting the source of supply may be a circuit breaker, circuit switches, fuse, thyristor blocking in association with a circuit breaker, or other reasonable methods either locally or remotely connected to the transformer. This includes disconnecting the generator electric field source together with the source of mechanical energy upon detection of a fault in either the generator step-up or station auxiliary transformer. Removing a single phase rather than all three phases to extinguish short-circuit current is acceptable.

NOTE: Transformers other than power transformers are exempt from this rule. This includes instrument transformers, neutral earthing transformers, regulating transformers and other transformers specifically for control, protection, or metering.

6.2.2 Switchgear and metal-enclosed busbar

6.2.2.1 Switchgear assemblies

(a) General requirements for all switchgear

i) To minimise movement, all switchgear shall be secured in a manner consistent with its conditions of service and applicable manufacturer's instructions.

ii) Cable routed to switchgear shall be supported to minimise forces applied to conductor terminals.

iii) Piping containing liquids, or corrosive or hazardous gases, shall not be routed in the vicinity of switchgear unless suitable barriers are installed to protect the switchgear from damage in the event of a pipe failure.

iv) Switchgear shall not be located where foreign flammable or corrosive gases or liquids routinely and normally are discharged. Companion equipment such as transformers and switchgear are not considered foreign.

v) Switchgear should not be installed in a location that is still specifically under active construction, especially where welding and burning are required directly overhead. Special precautions should be observed to minimise impingement of slag, metal filings, moisture, dust, or hot particles.

NOTE: Switchgear may be installed in a general construction area if suitable temporary protection is provided to minimise the risks associated with general construction activities.

vi) Precautions shall be taken to protect energised switchgear from damage when maintenance is performed in the area.

vii) Switchgear enclosure surfaces shall not be used as physical support for any item unless specifically designed for that purpose.
viii) Enclosure interiors shall not be used as storage areas unless specifically designed for that purpose.
ix) Metal instrument cases shall be effectively earthed, enclosed in covers that are metal and effectively earthed, or are of insulating material.
x) All parts of any switchgear and of electrical connections shall be of sufficient mechanical strength and current carrying capacity to prevent danger.
xi) All live parts of any switch gear and connections shall be so enclosed or otherwise protected as to prevent danger to persons accidentally coming into contact therewith or danger from a deposit thereon of dust, water or other matter.

(b) Metal-enclosed power switchgear

i) Switchgear shall not be located within 7.6 m horizontally indoors or 3.0 m outdoors of storage containers, vessels, utilisation equipment, or devices containing flammable liquids or gases.

NOTE 1: If an intervening barrier, designed to mitigate the potential effects of flammable liquids or gases, is installed, the distances listed above do not apply

NOTE 2: The restrictions are not intended to apply to the power transformer(s) supplying the switchgear.

ii) Enclosed switchgear rooms shall have at least two means of egress, one at each extreme of the area, not necessarily in opposite walls. Doors shall swing out and be equipped with panic bars, pressure plates, or other devices that are normally latched but open under simple pressure.

NOTE: One door may be used when required by physical limitations if means are provided for unhampered exit during emergencies.

iii) Space shall be maintained in front of switchgear to allow breakers to be removed and turned without obstruction.
iv) Space shall be maintained in the rear of the switchgear to allow for door opening to at least 90 degrees open, or a minimum of 900 mm without obstruction when removable panels are used.
v) Permanently mounted devices, panel boards, etc., located on the walls shall not encroach on the space requirements in (b) iv) above.
vi) Where columns extend into the room beyond the wall surface, the face of the column shall not encroach on the space requirements in (b) iv) above.
vii) Low-voltage cables or conductors, except those to be connected to equipment within the compartment, shall not be routed through the medium or high voltage divisions of switchgear unless installed in rigid metal conduit or isolated by rigid metal barriers.
viii) Low-voltage conductors routed from medium or high voltage sections of switchgear shall terminate in a low-voltage section before being routed external to the switchgear.
ix) Conductors entering switchgear shall be insulated from the higher operating voltage in that compartment or be separated from insulated conductors of other voltage ratings.
x) Switchgear enclosures shall be suitable for the environment in which they are installed.
xi) A safety sign shall be placed in each cubicle containing more than one voltage source.
xii) The location of control devices shall be readily accessible to personnel. Instruments, relays, and other devices requiring reading or adjustments should be so placed that work can readily be performed from the working space.

(c) Motor control centres

i) Motor Control Centres shall not be connected to systems having higher short-circuit capability than the bus bracing can withstand. Where current-limiting fuses are employed on the source side of the bus, the bus bracing and breaker-interruption rating are determined by the peak let-through characteristic of the current-limiting fuse.
ii) A safety sign shall be placed in each cubicle containing more than one voltage source.

(d) Control switchboards

i) Cabinets containing solid-state logic devices, electron tubes, or relay logic devices such as boiler analogue, burner safety, annunciators, computers, inverters, precipitator logic, soot blower control, load control, tele-metering, totalising microwave radio, etc., are covered under this Standard.
ii) Where carpeting is installed in rooms containing control switchboards, it shall be of an antistatic type and shall minimise the release of noxious, corrosive, caustic, or toxic gas under any condition.
iii) Layout of the installation shall provide adequate clearance in front of, or rear of, panels if applicable, to allow meters to be read without use of stools or auxiliary devices.
iv) Where personnel access to control panels such as bench boards, is required, cables shall be routed through openings separate from personnel opening. Removable, sliding, or hinged panels are to be installed to close the personnel opening when not in use.

6.2.2.2 Metal-enclosed busbar

(a) General requirements for all types of busbar

i) Busbars shall be installed only in accessible areas.
ii) Busbars, unless specifically approved for the purpose, shall not be installed: where subject to severe physical damage or corrosive vapours; in hoist ways; in any classified hazardous location; outdoors or in damp locations.
iii) Dead-ends of busbars shall be enclosed.
iv) Busbars shall be marked with the voltage, current rating for which they are designed, in such manner as to be visible after installation. The phases shall also be appropriately marked for easy identification.

(b) Isolated-phase busbar

i) The minimum clearance between an isolated-phase bus, and any magnetic material shall be the distance recommended by the manufacturer to avoid overheating of the magnetic material.
ii) Non-magnetic conduit should be used to protect the conductors which are for bus-alarm devices, thermocouples, space heaters, etc., if routed within the manufacturer's recommended minimum distance to magnetic material and parallel to isolated-phase bus bar enclosures.
iii) When enclosure drains are provided for isolated-phase bus bars necessary piping shall be provided to divert water away from electrical equipment.
iv) Wall plates for isolated-phase busbars shall be nonmagnetic, such as aluminium or non-ferrite stainless steel.
v) Earthing conductors for isolated-phase busbar accessories should not be routed through ferrous conduit.

6.2.2.3 Surge arresters

(a) General requirements

If arresters are required, they shall be located as close as practicable to the equipment they protect.

(b) Indoor locations

Arresters, if installed inside of buildings, shall be enclosed or shall be located well away from passageways and combustible parts.

(c) Earthing conductors

Earthing conductors shall be run as directly as practicable between the arresters and earth and be of low impedance and ample current-carrying capacity in accordance with ZS 691.

(d) Installation

Arresters shall be installed in such a manner and location that neither the expulsion of gases nor the arrester disconnector is directed upon live parts in the vicinity.

6.3 Cables

6.3.1 Trenching

6.3.1.1 Direct-buried cable

The bottom of the trench receiving direct-buried cable should be relatively smooth, undisturbed earth; well-tamped earth; or sand. When excavation is in rock or rocky soils, the cable shall be laid on a protective layer of well-tamped backfill. Backfill within 100 mm of the cable shall be free of materials that may damage the cable. Backfill shall be adequately compacted. Machine compaction shall not be used within 150 mm of the cable.

6.3.1.2 Cable in duct

For cable installed in a duct, the bottom of the trench should be in undisturbed, tamped, or relatively smooth earth. Where the excavation is in rock, the duct shall be laid on a protective layer of clean tamped backfill. All backfill shall be free of materials that may damage the duct. Backfill shall be adequately compacted to limit settling under the expected surface usage.

6.3.2 Ploughing

(a) Ploughing in of cable in soil containing rock or other solid material shall be done in such a manner that the solid material will not damage the cable, either during the ploughing operation or afterward.

(b) The design of cable-ploughing equipment and the ploughing-in operation shall be such that the cable will not be damaged by bending, side-wall pressure, or excessive cable tension.

6.3.3 Boring

Where a cable system is to be installed by boring and the soil and surface loading conditions are such that solid material in the region may damage the cable, the cable shall be adequately protected.

6.3.4 Depth of burial

(a) The distance between the top of a cable and the surface under which it is installed (depth of burial) shall be sufficient to protect the cable from damage imposed by expected surface usage.

(b) Supply cable or duct shall have burial depths not less than the values indicated in Table 6-1. Where the burial depths required cannot be met, lesser depths than indicated in Table 6-1 may be used if supplemental mechanical protection is provided. The supplemental mechanical protection shall be sufficient to protect the cable or duct from damage imposed by expected surface usage. Where the cable is installed in duct, additional supplemental mechanical protection is not required if the duct is of sufficient strength to protect the cable from expected surface usage.

NOTE: Cable depths at the time of installation may need to be adjusted to meet known grade changes.

Table 6-1: Depth of burial

Voltage (Phase-to-phase)	Depth of burial (mm)
0 to 1000	600
Above 1000 up to 66000	750
Above 66000	1070

NOTE: Street light cables operating at not more than 230V to earth may be buried at a depth not less than 450 mm

6.3.5 Marking of buried cables

(a) The cable shall be marked with continuous PVC marker tape marked in legible lettering, **"CAUTION – BURRIED CABLE"**, or similar, along the centre line of each cable.

(b) The route of all underground cables shall be marked with concrete cable route markers along the cable route at 50 m spacing between markers and at all changes of direction. The markers shall have a plate bearing the words **"ELECTRIC CABLES"**, identification mark of the enterprise and directional arrows.

6.4 Overhead lines

6.4.1 General requirements

6.4.1.1 Accessibility

All parts that must be examined or adjusted during operation shall be arranged so as to be accessible to authorised persons by the provision of adequate climbing spaces, working spaces, working facilities, and clearances between conductors.

6.4.1.2 Inspection and tests of lines and equipment

(a) When in service

i) Initial compliance with requirements

Lines and equipment shall comply with these safety requirements when placed in service.

ii) Inspection

Lines and equipment shall be inspected at such intervals as experience has shown to be necessary.

NOTE: It is recognised that inspections may be performed in a separate operation or while performing other duties, as desired.

iii) Tests

When considered necessary, lines and equipment shall be subjected to practical tests to determine required maintenance.

iv) Inspection records

Any defects or conditions affecting compliance with this code revealed by inspection or tests, if not promptly corrected, shall be recorded. Such records shall be maintained until the conditions or defects are corrected.

v) Corrections

Lines and equipment with recorded conditions or defects that would reasonably be expected to endanger life or property shall be promptly corrected, disconnected, or isolated.

(b) When out of service

i) Lines infrequently used

Lines and equipment infrequently used shall be inspected or tested as necessary before being placed into service.

ii) Lines temporarily out of service

Lines and equipment temporarily out of service shall be maintained in a safe condition.

iii) Lines permanently abandoned

Lines and equipment permanently abandoned shall be removed or maintained in a safe condition.

6.4.1.3 Earthing and bonding

(a) Methods

Earthing shall be in accordance with the applicable methods given in ZS 691.

(b) Earthing of circuits

i) Common neutral

A conductor used as a common neutral for primary and secondary circuits shall be effectively earthed.

ii) Other neutrals

Primary line, secondary line, and service neutral conductors shall be effectively earthed, except;

1. Circuits designed for earth-fault detection and impedance-current-limiting devices; or
2. Primary circuits designed with a single point earthed neutral. This type of neutral conductor is not an effectively earthed neutral conductor.

iii) Other conductors

Line or service conductors, other than neutral conductors, that are intentionally earthed, shall be effectively earthed.

iv) Surge arresters

Where the operation of surge arresters is dependent upon earthing, they shall be effectively earthed.

v) Use of earth as part of circuit

1. Supply circuits shall not be designed to use the earth normally as the sole conductor for any part of the circuit.
2. Mono-polar operation of a bipolar High Voltage Direct Current (HVDC) system is permissible for emergencies and limited periods for maintenance.

(c) Earthing of non-current-carrying parts

i) General

Metal or metal-reinforced supporting structures, including lamp posts;, metal ducts, conduits and raceways; cable sheaths; messengers; metal frames, cases, and hangers of equipment; and metal switch handles and operating rods shall be effectively earthed.

NOTE 1: This requirement does not apply to frames, cases, and hangers of equipment and switch handles and operating rods that are 2.5 m or more above readily accessible surfaces or are otherwise isolated or guarded and where the practice of not earthing such items has been a uniform practice over a well-defined area.

NOTE 2: This requirement does not apply to isolated or guarded equipment cases in certain specialised applications, such as series capacitors where it is necessary that equipment cases be either unearthed or connected to the circuit. Such equipment cases shall be considered as energised and shall be suitably identified.

NOTE 3: This requirement does not apply to equipment cases, frames, equipment hangers, conduits, messengers, raceways, and cable sheaths enclosing or supporting only communication conductors, provided they are not exposed to contact with open supply conductors of over 300 V.

ii) Stay wires

1. Stay wires shall be effectively earthed if attached to a supporting structure carrying any supply conductor of more than 300 V or if vulnerable to accidental energisation by such conductors due to a slack conductor or stay.

2. Stay wires and stay insulators shall be of suitable materials made of wet-process porcelain, wood, fibre-reinforced polymer, or other materials of suitable mechanical and electrical properties. The materials shall be of adequate electrical strength and be designed with a dry flashover voltage of at least double, and a rated wet flashover voltage of at least as high as the voltage to which the insulator may be exposed. The rated ultimate strength of the stay insulator shall be at least equal to the required strength of the stay wire in which it is installed and the rated ultimate strength of the span-wire insulator shall be at least equal to the required strength of the span wire in which it is located.

3. Stay insulators shall be positioned so as to limit the likelihood of any portion of a stay becoming energised within 2.5 m of the ground level in the event that the stay wire becomes slack or breaks.

6.4.1.4 Arrangement of switches

(a) Accessibility

Switches or their control mechanisms shall be installed so as to be accessible to authorised persons.

(b) Indicating open or closed position

Switch position shall be visible or clearly indicated.

(c) Locking

Switch-operating mechanisms that are accessible to unauthorised persons shall have provisions for locking in each operational position and shall be locked or otherwise secured except during operation or testing.

(d) Uniform position

The handles or control mechanisms for all switches throughout any system shall have consistent positions when opened and uniformly different positions when closed in order to minimise operating errors. Where this practice is not followed, the switches shall be marked to minimise mistakes in operation.

(e) Remote operation

Remotely controlled, automatic transmission, or distribution overhead line switching devices shall have local provisions to render remote or automatic controls inoperable.

6.4.1.5 Supporting structures

(a) Protection of structures

i) From vehicular damage

Appropriate physical protection shall be provided for supporting structures in established parking areas, in alleys, or next to driveways subject to vehicular traffic abrasion that would materially affect their strength. Physical protection is not required for supporting structures located outside of established parking areas, alleys, or driveways.

ii) Fire

Supporting structures shall be placed and maintained so as to be exposed as little as is practicable to shrubs, grass, rubbish, or building fires.

iii) Attached to bridges

Supporting structures attached to bridges for the purpose of carrying bare conductors exceeding 1000 V shall be posted with appropriate safety signs.

(b) Readily climbable supporting structures

i) Readily climbable supporting structures, such as closely latticed poles, towers, or bridge attachments, carrying bare conductors, which are adjacent to roads, regularly travelled pedestrian thoroughfares, or places where persons frequently gather (such as schools or public playgrounds), shall be equipped with barriers to inhibit climbing by unauthorised persons or posted with appropriate safety signs.

NOTE 1: This requirement does not apply where access to the supporting structure is limited by a fence meeting the height requirements.

NOTE 2: This requirement shall apply to wooden pole mounted transformers structures.

ii) Steps permanently installed on supporting structures shall not be closer than 2.5 m from the ground or other accessible surface.

Where steps are temporarily installed less than 2.5 m from the ground or other accessible surface, structures shall be attended or barriers to inhibit climbing by unauthorised persons shall be installed.

NOTE 1: This does not apply where supporting structures are isolated.

NOTE 2: This does not apply where access to the supporting structure is limited by a fence meeting the height requirements.

(c) Riser standoff brackets

Standoff brackets on supporting structures shall be arranged so that there is not less than 2.5 m between either:

i) The lowest bracket and ground or other permanently installed accessible surface; or
ii) The two lowest brackets.

NOTE: This rule does not apply where supporting structures are isolated.

(d) Equipment and associated support brackets

Equipment shall be installed so that there is not less than 2.5 m between either:

i) The lowest equipment support bracket and ground or other permanently installed accessible surface; or
ii) The highest equipment support bracket or top surface of equipment and any handhold located above it.

NOTE: This does not apply where supporting structures are isolated.

(e) Identification

Supporting structures, including those on bridges, on which supply or communication conductors are maintained, shall be so constructed, located, marked, or numbered so as to facilitate identification by authorised persons to work thereon.

(f) Attachments, decorations, and obstructions

No attachment of any kind to a supporting structure of a utility line (including lighting and metering structures) shall be allowed without the consent of the structure owner. Non-utility attachments shall also have consent of the occupant(s) of the space in which the attachment is made.

i) No attachment shall cause any portion of the resulting installation to be in noncompliance with the clearance, grounding, strength, or other regulatory requirements.
ii) Attachments shall neither obstruct the climbing space nor present a climbing hazard to utility personnel. Through-bolts shall be properly trimmed. Vines, nails, tacks, or other items which may interfere with climbing should be removed before climbing.

(g) Unusual conductor supports

i) Where line conductors are attached to structures other than those used solely or principally for their support, all rules shall be complied with as far as they apply. Such additional precautions as may be deemed necessary by the regulator shall be taken to avoid damage to the structures or injury to the persons using them.
ii) The supporting of conductors on trees and roofs shall be avoided.

(h) Protection and marking of stay wires

i) The ground end of each stay wire adjacent to regularly travelled pedestrian walkways, or places where persons are normally encountered or reasonably anticipated, shall be provided with a substantial and conspicuous marker.

NOTE: There is no intent to require markers at all stay wire locations.

ii) Where an anchor is located in an established parking area, the stay wire shall either be protected from vehicle contact or marked.

6.4.1.6 Vegetation management

(a) General

i) Vegetation management shall be performed around supply and communication lines. Vegetation that may damage unearthed supply conductors shall be pruned or removed.

NOTE 1: Factors to consider in determining the extent of vegetation management required include, but are not limited to: line voltage class, species' growth rates and failure characteristics, right-of-way limitations, the vegetation's location in relation to the conductors, the potential combined movement of vegetation and conductors during routine winds, and sagging of conductors due to elevated temperatures.

NOTE 2: It is not practicable to prevent all tree-conductor contacts on overhead lines.

ii) Where pruning or removal is not practicable, the conductor shall be separated from the tree with suitable materials or devices to avoid conductor damage by abrasion and grounding of the circuit through the tree.

(b) At line crossings, railroad crossings, limited-access highway crossings, or navigable waterways requiring crossing permits

The crossing span and the adjoining span on each side of the crossing shall be kept free from over-hanging or decayed trees or limbs that otherwise might fall into the line.

6.4.2 Relations between various classes of lines and equipment

6.4.2.1 Standardisation of levels

The levels at which different classes of conductors are to be located shall be standardised in line with applicable regulations.

6.4.2.2 Relative levels: supply and communication conductors and equipment

(a) Preferred levels

Where supply and communication conductors/cables or equipment are located on the same supporting structure or crossing each other in the span, the supply conductors or equipment should be carried at the higher level.

NOTE: This does not apply to any of the following:

i. Trolley feeders located for convenience approximately at the level of the trolley-contact conductor,
ii. Antennas located in the supply space or a communication space, in accordance with clearances in relevant applicable standards,
iii. Effectively earthed switch handles and equipment cases (such as fire alarm boxes, control boxes, communication terminals, meters, or similar equipment cases, which may be mounted at a lower level in accordance with relevant applicable standards, or
iv. Communication cables located within a supply space in accordance with clearances in accordance with relevant applicable standards.

(b) Special construction for railroad supply circuits of 1000 V or less and carrying power not in excess of 5 kW associated with railroad communication circuits

Where all circuits are owned or operated by one party or where cooperative consideration determines that the circumstances warrant and the necessary coordinating methods are employed, single-phase ac or two-wire dc circuits carrying a voltage of 1000 V or less between conductors, with transmitted power not in excess of 5 kW, where located on structures with communication circuits, may be installed under the following conditions:

i) That such supply circuits are of covered conductor not smaller than 10.0 mm^2 medium hard-drawn copper or its equivalent in strength, and the construction otherwise conforms with the requirements for supply circuits of the same class;
ii) That the supply circuits be placed on the end and adjacent pins of the lowest through signal support arm and that a 750 mm climbing space be maintained from the ground up to a point at least 600 mm above the supply circuits. The supply circuits shall be rendered conspicuous by the use of insulators of different form or colour from others on the pole line or by stencilling the voltage on each side of the support arm between the pins carrying each supply circuit, or by indicating the voltage by means of metal characters;
iii) That there shall be a vertical clearance of not less than 600 mm between the support arm carrying these supply circuits and the next support arm above. The other pins on the support arm carrying the supply circuits may be occupied by communication circuits used in the operation or control of signal system or other supply system if owned, operated, and maintained by the same enterprise operating the supply circuits;
iv) That such supply circuits shall be equipped with arresters and fuses installed in the supply end of the circuit and where the signal circuit is ac, the protection shall be installed on the secondary side of the supply transformer. The arresters shall be designed so as to break down at approximately twice the voltage between the wires of the circuit, but the breakdown voltage of the arrester need not be less than 1 kV. The fuses shall have a rating not in excess of approximately twice the maximum operating current of the circuit, but their rating need not be less than 10 A. The fuses likewise in all cases shall have a rating of at least 1000 V, and where the supply transformer is a step-down transformer, shall be capable of opening the circuit successfully in the event the transformer primary voltage is impressed upon them.
v) Such supply circuits may be installed below communication attachments, with not less than 400 mm vertical clearance between the supply cable and the lowest communication attachment. Communication circuits other than those used in connection with the operation of the supply circuits shall not be carried in the same cable with such supply circuits.
vi) Where such supply conductors are carried below communication conductors, transformers and other apparatus associated therewith shall be attached only to the sides of the support arm in the space between and at no higher level than such supply wires.
vii) Lateral runs of such supply circuits carried in a position below the communication space shall be protected through the climbing space by wood moulding or equivalent covering, or shall be carried in insulated multiple-conductor cable, and such lateral runs shall be placed on the underside of the support arm.

6.4.2.3 Relative levels: Supply lines of different voltage classifications

(a) At crossings or conflicts

Where supply conductors of different voltage classifications cross each other or structure conflict exists, the higher-voltage lines shall be carried at the higher level.

(b) On structures used only by supply conductors

Where supply conductors of different voltage classifications are on the same structures, relative levels shall be as follows:

i) Where all circuits are owned by one utility, the conductors of higher voltage shall be placed above those of lower voltage; and
ii) Where different circuits are owned by separate utilities, the circuits of each utility shall be grouped together, and one group of circuits shall be placed above the other group provided that the circuits in each group are located so that those of higher voltage are at the higher levels and that horizontal and vertical clearances of not less than those required in applicable regulations are maintained between the nearest line conductors of the respective utilities.

6.4.2.4 Identification of overhead conductors and cables

All conductors and cables of electric supply and communication lines shall, as far as is practicable, be arranged to occupy uniform positions throughout, or shall be constructed, located, marked, numbered, or attached to distinctive insulators or crossarms, so as to facilitate identification by authorised persons to work thereon.

NOTE: This does not prohibit systematic transposition of conductors.

6.4.2.5 Identification of equipment on supporting structures

All equipment of electric supply and communication lines shall be arranged to occupy uniform positions throughout or shall be constructed, located, marked, or numbered so as to facilitate identification by authorised persons to work thereon.

7 COMMISSIONING

Commissioning of all electrical systems specified in this standard shall follow the prescribed procedures by the equipment manufacturer, requirements of this code and other applicable Zambian grid codes.

7.1 Testing

(a) Before any electrical installation is put into service, it must be inspected and proof tested by a competent person.

NOTE: Testing of any electrical installation and or associated components shall be done in such a manner as not to interfere with the safe operations of the existing installation.

(b) The person who carries out the test and inspection must be a competent person, and must be able to ensure his own safety, as well as that of others in the vicinity. It follows that he must be skilled and have experience of the type of installation to be inspected and tested so that there will be no accidents during the process to people, livestock, or property.

7.2 Reporting

A test or inspection made in terms of this clause shall be recorded by the person making the test or inspection and such record shall be made available upon request by relevant authorities.