NIGERIAN ELECTRICITY SUPPLY AND INSTALLATION STANDARDS REGULATIONS 2025

REGULATION NO: XXXX

In exercise of the powers to establish or, as the case may be approve appropriate operating Codes and Standards conferred by Sections 34(2)(b) of the Electricity Act 2023 and all other powers enabling it in that behalf, the Nigerian Electricity Regulatory Commission makes the following Regulations for Engineering Designs, Installations, Commissioning and Maintenance of electric power systems in the Nigerian Electricity Supply Industry.

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1.1

1.1 Introduction

This introduction does not form part of these Regulations. The Regulations are compendia of standards for the design, construction and commissioning of electrical infrastructure in the Nigerian Electricity Supply Industry approved by the Nigerian Electricity Regulatory Commission to replace the Electricity Supply (S. I. 5) Regulations and the Electrical Installation Regulations (S.I.6) of 1996 issued under the repealed Electricity Act. The Commission derived its power to repeal these Regulations from Section 98 of the Electric Power Sector Reform Act 2005. The new Regulations shall be known as the "Nigerian Electricity Supply and Installation Standards (NESIS) Regulations".

These Regulations include areas on design, construction, and commissioning of the power system in Nigeria through the value chain of electricity generation, transmission, distribution and utilisation not covered in Grid Code, Distribution Code, Nigeria Metering Code and Nigerian Electricity Health & Safety Code as amended. Fundamentally, it covers standards of materials, equipment and process with normative references to the Electricity Act 2023 , NERC technical Codes, NIS, IEEE, NIS IEC standards, and more as enumerated in the Normative Reference.

A Technical Working Group (TWG-NESIS Regulations) under the leadership of the Nigerian Society of Engineers (Nigerian Institution of Electrical Electronics Engineers-A Division of the Nigerian Society of Engineers) was formed with the sole responsibility of producing a draft Regulation to replace the S.I.5 and S. I. 6 Regulations. Four subcommittees of the TWG-NESIS Regulation produced the draft in five sessions over a period of fifteen months. The subcommittees are Transmission, Distribution, User's Site and Generation committees.

1.2 Scope

This document describes the requirements regulating the generation, transmission, distribution, and user's site standards, guides, and recommended practices for use in the Nigerian Electricity Supply Industry (NESI).

1.3 Normative References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of these Standards. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on these Standards are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below; NIS IEC

Electricity Act 2023 (Electric Power Sector Reform Act 2005),

NEMSA Act 2015 (Nigerian Electricity Management Service Agency 2015)

B.S. 125, 1970: for Copper or Copper Equivalent

B.S. 215 Part 1 197-for Aluminium

BS 5950: Structural use of steelwork in building code of practice for design rolled and welded sections

BS 7671-2008: Requirements for Electrical Installations

BS 8004: Foundations for the Design and construction of Injection Substation foundations

BS 8007: Code of practice for design of concrete structures for retaining aqueous liquids
BS 5628: Block Work/Brickwork for the design and Construction of block work/brickwork

BS 8110: Concrete Structural works

BS5266-1 -Where indoor lighting is designated for emergency purposes in such places as hospitals, entertainment venues, schools, industrial premises, hotels amongst others

Distribution Code

Grid Code

NIS IEC 60028: International standard of resistance for copper

NIS IEC 60038: NIS IEC standard voltages

NIS IEC 60044: Instrument transformers

NIS IEC 60044-1: Instrument transformers - Part 1: Current transformers

NIS IEC 60044-2 (2000-1): Instrument transformers - Part 2: Inductive voltage transformers

NIS IEC 60044-2: Instrument transformers - Part 2: Inductive voltage transformers

NIS IEC 60060: High-voltage test techniques - ALL PARTS

NIS/NIS IEC 60076-1: Power transformers - Part 1 General

NIS/NIS IEC 60076-10, Power transformers – Part 10-1: Determination of sound levels – Application guide

NIS/NIS IEC 60076-13, Power transformers – Part 13: Self-protected liquid-filled transformers

NIS/NIS IEC 60076-14, Power transformers – Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials

NIS/NIS IEC 60076-2: Power transformers – Part 2: Temperature rise for liquid-immersed transformers

NIS/NIS IEC 60076-3: Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air

NIS/NIS IEC 60076-4, Power Transformers-Part 4: Guide to the lightning impulse and switching impulse testing-power transformers and reactors

NIS/NIS IEC 60076-5, Power transformers: Ability to withstand short circuit

NIS/NIS IEC 60076-6, Power transformers – Part 6: Reactors

NIS/NIS IEC 60076-7, Power transformers – Part 7: Loading guide for oil immersed power transformers

NIS/NIS IEC 60076-8, Power transformers – Application guide

NIS IEC 60079-(All Parts): Explosive atmospheres

NIS IEC 60099 - Lightning or surge arrester devices for protection of all substations, intersection of overhead lines and underground cables from lightning and switching surges

NIS IEC 60099 -6: Surge arresters - Part 6: Surge arresters containing both series and parallel gapped structures - Rated 52 kV and less

NIS IEC 60099-4: Surge Arresters: Metal-oxide surge arresters without gaps for a.c. systems

NIS IEC 60099-5: Surge arresters - Part 5: Selection and application recommendations

NIS IEC 60099-8: Surge arresters - Part 8: Metal-oxide surge arresters with external series gap (EGLA) for overhead transmission and distribution lines of a.c. systems above 1 kV

NIS IEC 60104: Aluminium-magnesium-silicon alloy wire for overhead line conductors

NIS IEC 60143-1: Series capacitors for power systems - Part 1: General

NIS IEC 60173: Colours of the cores of flexible cables and cords: High-voltage switchgear and control gear - Part 202: High-voltage/ low-voltage prefabricated substation

NIS IEC 60185: Current Transformer

NIS IEC 60186: Voltage Transformer

NIS/NIS IEC 60227: Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – All Parts

NIS/NIS IEC 60228: Conductors of insulated cables

NIS IEC 60255-1: Measuring relays and protection equipment - Part 1: Common requirements

NIS IEC 60273: Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V

NIS IEC 60282-1: High-voltage fuses - Part 1: Current-limiting fuses

NIS IEC 60282-2: High-voltage fuses - Part 2: Expulsion fuses

NIS IEC 60289: Reactors

NIS IEC 60296- Fluids for electro-technical applications - Unused mineral insulating oils for transformers and switchgear

NIS IEC 60298: High-voltage metal-enclosed switchgear and control gear

NIS IEC 60335-2-75-Households and similar electrical appliances particular requirement for commercial dispensing appliances and bending machines

NIS IEC 60335-2-76: Household and similar electrical appliances - Safety - Part 2-76: Particular requirements for electric fence energizers

NIS IEC 60364-5-54: Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements and protective

NIS IEC 60364-7-701: Low-voltage electrical installations - Part 7-701: Requirements for special installations or locations - Locations containing a bath or shower

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

NIS IEC 60364-7-705: Low-voltage electrical installations - Part 7-705: Requirements for special installations or locations - Agricultural and horticultural premises

NIS IEC 60364-7-711: Electrical installations of buildings - Part 7-711: Requirements for special installations or locations - Exhibitions, shows and stands

NIS IEC 60383-1: Insulators for overhead lines with a nominal voltage above 1000 V - Part 1: Ceramic or glass insulator units for a.c. systems - Definitions, test methods and acceptance criteria

NIS IEC 60502-2: Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)

NIS IEC 60529: Degrees of protection provided by enclosures (IP Code)

NIS IEC 60598-2-3: Luminaires - Part 2-3: Particular requirements - Luminaires for road and street lighting NIS IEC 60092-306: Electrical installations in ships - Part 306: Equipment - Luminaires and lighting accessories

NIS IEC 60694: Common clauses for high-voltage switchgear and control gear standards.

NIS IEC 60726: Dry-type power transformers

NIS IEC 60826: Design criteria of overhead transmission lines

NIS IEC 60840: Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) - Test methods and requirements

NIS IEC 60870: Telecontrol equipment and systems

NIS IEC 60870-(All Parts) - Telecontrol equipment and systems

NIS IEC 60871-Shunt capacitors for ac power systems

NIS IEC 60888: Zinc-coated steel wires for stranded conductors

NIS IEC 60889: Hard-drawn aluminium wire for overhead line conductors

NIS IEC 60898: Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations

NIS IEC 60947: Low Voltage Switchgear and Controlgear

NIS IEC 60947-1: Low-voltage switchgear and control gear - Part 1: General rules

NIS IEC 60947-2: Low-voltage switchgear and control gear - Part 2: Circuit-breakers

NIS IEC 61089: Round wire concentric lay overhead electrical stranded conductors

NIS IEC 61232: Aluminium-clad steel wires for electrical purposes

NIS IEC 61400-Dynamic Voltage Restorers or Series Voltage Booster device installed to mitigate against voltage sags, spikes, harmonics and in-voltage variations

NIS IEC 61810-1: Electromechanical relays used on distribution substation switchgears

NIS IEC 61810-7: Electromechanical elementary relays - Part 7: Test and measurement procedures

NIS IEC 61850: Communication networks and systems in substations - ALL PARTS

NIS IEC 61869-1,2,3: Instrument transformers

NIS IEC 61954 Static VAr Compensator installed on medium voltage distribution for power quality improvement of the network

NIS IEC 62068: Electrical insulating materials and systems - General method of evaluation of electrical endurance under repetitive voltage impulses

NIS IEC 62128-1, 2, 3 - Bypass Isolators-Protective device for electrical safety

NIS IEC 62271-100: High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers

NIS IEC 62271-102: Alternating current disconnectors and earthing switches

NIS IEC 62271-200: High-voltage switchgear and control gear - Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV

NIS IEC 62271-4: High-voltage switchgear and control gear - Part 4: Handling procedures for sulphur hexafluoride (SF6) and its mixtures

NIS IEC 62305-(All Parts): Protection against lightning

NIS IEC60947-1: Low-voltage switchgear and control gear - Part 1: General rules

NIS IEC-61439: Low-voltage switchgear and controlgear assemblies - Part 0: Guidance to specifying assemblies

IEEE 1031 – 2011: IEEE Guide for the Functional Specification of Specifications Transmission Static Var Compensators

IEEE 519: Guide for Harmonic Control and Reactive Compensation of Static Power Converters

Nigeria Metering Code

NCP 9: National Code of Practice on Earthing

NEHSC Nigerian Electricity Health & Safety Code Version 01

Nigerian National Building Code (NNBC)

Nigerian Communication Commission (NCC) - Specification for communication towers

Nigerian Environmental Laws

NIS NIS IEC 60081: Double-capped fluorescent lamps - Performance specifications

NIS NIS IEC 60186: Inductive voltage dividers

NIS NIS IEC 60204: Safety of machinery - Electrical equipment of machines - ALL PARTS

NIS NIS IEC 60228: Conductors of insulated cables

NIS NIS IEC 60335: Household and similar electrical appliances

NIS NIS IEC 60557-Dissolved gas analysis carried out on all transformers periodically

NIS NIS IEC 60884: Plugs and socket-outlets for household and similar purposes - Part 1: General requirements

NIS NIS IEC 60974-9: Arc welding equipment - Part 9: Installation and use

NIS NIS IEC 61000-3-11: Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current ≤ 75 A and subject to conditional connection

NIS NIS IEC 61850: Communication networks and systems in substations - ALL PARTS

Reporting Compliance Regulations 2009

All Publications referred to above, herewith, shall be considered as "All Parts" unless otherwise stated.

1.4 Definition of Terms

Word	Definition
Annealed	Toughened metal or glass by heating and slow cooling
Arcing Horn	(Sometimes arc-horns) are projecting conductors used to protect insulators on high voltage electric power transmission systems from damage during flashover.
AVC	Adaptive VAR Compensator
Bayonet cap	Cap (international designation B) with bayonet pins on its shell which engage in slots in a lamp holder
Buchholz	Is a gas and oil operated device installed in the pipe-work between the top of the transformer main tank and the conservator
Building-to-land ratio	means the ratio of (the area covered with buildings / 50,000 m2 MINUS the area of roads] in the zone (excluding roads) that is the rectangular area of 50,000 m2 extending for 50 m on both sides of an overhead transmission line and 500 m in the direction of that line.
Captive	Generation of electricity for the purpose of consumption by a licensee itself

Generation	and not sold to a third party
Catenary	a longitudinal cable supporting the contact wire or wires either directly or indirectly
Consumer	means any end user of electricity who is a customer of a distribution licensee that is not an eligible customer and, for purposes of filing a complaint with the Commission and for any other reason that the Commission may determine, a person who is temporally disconnected or otherwise without service, provided that a person who has applied for, but has yet to receive, service shall also be deemed to be a consumer
COREN	Council for the Regulation of Engineering in Nigeria
COREN Affiliated Institutions	Means the Nigerian Society of Engineers (NSE), Nigerian Association of Technologist in Engineering (NATE), Nigerian Society of Engineering Technicians (NISET), Nigerian Association of Engineering Craftsmen (NAEC)
CT	Current Transformer
D – Iron	Mechanical support for low tension overhead lines manufactured and fabricated in the form of D shape to provide support for the porcelain insulators
Derogation	Derogation is a directive from the Nigerian Electricity Regulatory Commission (NERC) relieving a licensee from its obligation to comply with a technical standard or code in its licence in specified circumstances and to a specified extent
Earth mat	Earth mat is an earth electrode that is manufactured or fabricated in the form of a mat.
Electricity Utilit	Entity of the Generation or Transmission or Distribution Companies
EMS	Energy Management System
EPSR	Electric Power Sector Reform
Equi-Potential	Refers to a region in space where every point in it is at the same potential; always perpendicular to the electric field
Extraneous	Conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

Fireproof	"Fireproof" means the materials that flame in fire, but do not spread at least.
Furan Analysis	Test on transformer oil that indicates the degree of depreciation of paper insulation.
Galvanized	Iron or Steel material coated with zinc.
Gantry	Gantry: A bridge like overhead structure supporting equipment such as a crane or a tall framework supporting a space rocket prior to launching.
Generating Station	means a station for generating electricity, including buildings, plant and machinery and all accessories used for that purpose and the site to be used for the station or accessories
GHG's	Greenhouse Gases
Grid Code	means instructions, rules, procedures, guidelines, etc., for the operation and planning of an interconnected power system and accounting requirements relating thereto
Guy assembly	Guy: a steel wire rope or rod, working under tension, connecting a point of a support to a separate anchor, or connecting two points of the support Assembly (electric) line: an arrangement of conductors, insulating materials and accessories for transferring electricity between two points of a system
HMI	Human–Machine Interface
HRFR	Heat-Resistant and Flame-Retardent
NIS IEC	International Electro technical Commission
Interposing Current Transformers	Interposing current transformers are low-tension transformers used to balance the secondary output from the primary high-tension current transformer for purposes of providing correct secondary current input for protective relay operations.
Interturn Fault	an insulation fault between neighbouring turns of the same winding in a coil
Interutility	Any transfer of allowances from one utility operating company's account to a different utility operating company's account, provided the operating companies are not controlled by the same parent company. Both transferor and transferee accounts can be either general or unit accounts.
ISO	International Organisation for Standardization
Isokeraunic	A line on a map that connects places of equal thunderstorm frequency

Kingbolts	A vertical iron bolt, by which the forward axle and wheels of a vehicle or the trucks of a railroad car are connected with the other parts.
Knee Point Voltage	is the maximum secondary voltage that the CT will provide to a standard burden without saturating the transformer
Lateral shearing	Shearing: to cut (something). Lateral: of or pertaining to the side; situated at, proceeding from, or directed to a side
Licensee	means any person who holds a licence issued under Part VI of the Electricity Act 2023 ;
Lighting Arresters	is a device used on electrical power systems and telecommunications systems to protect the insulation and conductors of the system from the damaging effects of lightning
LMU/LMDU	Line Matching Unit/Line Matching Distribution Unit: is a composite unit consisting of Drain Coil, Isolation transformer with lightning arresters on both sides, a Tuning Device and an Earth switch.
Lugs	Metallic device used to terminate single or multistrand cables before connecting it to a terminal or equipment.
Lux	SI unit of illuminance (luminance): Illuminance (luminance) produced on a surface of area 1 square metre by a luminous flux of 1 lumen uniformly distributed over that surface
LVAC	Low Voltage Alternating Current
Marshalling Boxes	Marshalling box is a type of box containing auxiliary equipment connected by cables to main substation equipment, e.g. power transformers. Such auxiliary equipment could be WTI (winding temperature indicator) and OTI (oil temperature indicator) of power transformers.
MCB	Miniature Circuit Breaker
NEMSA	Nigerian Electricity Management Services Agency
NNBC	Nigeria National Building Code
NCC	Nigerian Communications Commission
NIS	Nigerian Industrial Standards
Non-flammable	Non-flammable" means such materials as concrete, brick, tile, asbestos cement slate, steel, aluminium, glass, mortar and other materials that have

	incombustibility no less than that of these materials.
Opepe wood	A typical West African tree that yields timber that is used in harbor work because of its resistance to marine borers.
ORFR	Oil-Resisting and Flame-Retardant
PC	Personal Computer including Laptop Computers
Person	includes an individual, company, partnership or any other association of individuals, whether incorporated or not;
Pilot Cables	a control cable laid in parallel with a power cable and intended for transmitting signals related to the operation of that cable
Plant	
Prima facie	a Latin expression meaning accepted as correct until proved otherwise
RCC	Regional Control Centre
Sag	Is the vertical distance between the point where the line is connected to the support structure and the lowest point on the line
SCADA	Supervisory Control and Data Acquisition; a computer system for gathering and analyzing real time data
SCU	Substation Control Unit
Service Provider	Means Electricity utility, telecommunication Service Provider or Railway Services Provider
Self-extinguishing	Self-extinguishing" means materials that flame in fire and extinguish by themselves when fire is removed
SF_6	Sulphur hexafluoride (SF_6) is an inorganic, colourless, odourless, non-flammable, extremely potent greenhouse gas, which is an excellent electrical insulator.
SON	Standards Organisation of Nigeria
Switchgear	A combination of disconnects switches and breakers used to isolate or connect equipment in substations.
Synchronism	the state in which two time-varying phenomena, time-scales, or signals are identical
TRD	Technical Regulation Division of the Commission

Teleprotection	A protection scheme that incorporate protective relays with ability to communicate with each other to clear fault faster, increase fault sensitivity, and restore power quicker with fast reliable protect transmission lines with high speed distance and directional functions.
Termination kits	Electrical termination of an electric voltage involves providing a terminator at the end of a wire or cable to prevent a supply from being fed back from the end.
Toe compression	A steel-toe boot (also known as a safety boot, steel-capped boot or safety shoe) is a durable boot or shoe that has a protective reinforcement in the toe which protects the foot from falling objects or compression, usually combined with a mid sole plate to protect against punctures from below
Tower Footing Resistance	The Ohmic resistance between a transmission-line tower and the earth.
Trifurcation	The act of splitting into three branches
Vector Group	the NIS IEC method of categorizing the high voltage (HV) windings and low voltage (LV) winding configurations and angular displacement between them of three-phase transformers.
Vermin	pests or nuisance animals, especially those that threaten human society by spreading diseases.
Wide Area Protection	This is a protection type used to save the system from partial or total blackout or brownout in operational situations when no particular equipment is faulty or operated outside its limitations. The situation could appear after the clearance of a very severe disturbance in a stressed operation situation or after an extreme load growth. Since it is a protection system, it will operate in such operational situation when the power systems will breakdown if no protective actions were taken.

1.5 General Provisions

1.5.1 Compliance with the Nigerian Electricity Supply and Installation Standards Regulations

Any person engaged in the generation, transmission, distribution, system operation, and trading in electricity or in any aspect in the value chain of electricity supply, including but not limited to engineering designs, installations, commissioning, decommissioning and maintenance of electric power systems for the purpose of achieving safe and reliable supply, and utilization of electricity in Nigeria, shall comply with the provisions of the Electric Power Sector Reform (EPSR) Act 2005, Nigerian Electricity Management Services Agency (NEMSA) Act 2015, the Nigerian Electricity Supply and Installation Standards (NESIS) Regulations, license terms and conditions and all other Regulations, Codes, Standards made pursuant to the Electricity Act 2023

1.5.2 Qualification of Engineering Personnel

1.5.2.1 The minimum qualification of any person to be engaged or already engaged as an Engineering Personnel in any undertaking, or involved in any aspect of the electricity supply chain shall be any COREN registrable qualification.

1.5.3 Inspection of Electrical Facilities

1.5.3.1 Any licensee, undertaking or any person involved in the business of generation, transmission, distribution, trading, system operation, or any aspect of the electricity supply chain in NESI, shall ensure the regular inspection of electrical facilities within its area of operation in compliance with and in the manner provided in the "Inspection" provisions of the Electricity Act 2023 , NESIS Regulations, Distribution Code, Grid Code, Nigeria Metering Code, Nigerian Electricity Health & Safety Code and any other Regulation, Codes and Standards made pursuant to the Electricity Act 2023 Pursuant to Part V, Section (34)(1)(e) of the Electricity Act 2023, the Commission may appoint Inspectors to inspect electrical facilities to ensure safety of operations and compliance with the Electricity Act 2023, NESIS Regulations, Distribution Code, Grid Code, Nigeria Metering Code, Nigerian Electricity Health & Safety Code and other Regulations, Codes and Standards made pursuant to the Electricity Act.

1.5.4 Documentation and Reporting Obligations

1.5.4.1 Any licensee or any person in the business of electricity generation, transmission, distribution, trading, system operation or any other aspect of the electricity supply chain, shall ensure;

(i) The proper documentation of its activities and processes in accordance with the provisions of the Electricity Act 2023 , NESIS Regulations, Distribution Code, Grid Code, Nigeria Metering Code, Nigerian Electricity Health & Safety Code and other Regulations, Codes, and Standards applicable to it and made pursuant to the Electricity Act 2023 .

(ii) Compliance with reporting obligations in the Electricity Act 2023 , NESIS Regulations, Reporting Compliance Regulations 2009, Distribution Code, Grid Code, Nigeria

Metering Code, Nigerian Electricity Health & Safety Code and other Regulations, Codes and Standards applicable to it and made pursuant to the Electricity Act 2023 .

1.5.5 Enforcement and Penalty for non-compliance

1.5.5.1 Pursuant to Section 75 & 94 (1) of the Electricity Act 2023 and without prejudice to the Enforcement Regulations, any person who contravenes or violates any provisions of the NESIS Regulations commits an offence and is liable on conviction where no specific penalty is prescribed therefore:

i. As a first offender to a fine not exceeding N100, 000.00 (One Hundred Thousand Naira) only or to imprisonment for a period not exceeding 1(one) year or to both fine and imprisonment; or

ii. For subsequent convictions to a fine not exceeding N500, 000.00 (Five Hundred Thousand Naira) or to imprisonment for a period not exceeding 3 (three) years or to both fine and imprisonment.

1.5.5.2 Any person who:

(i) Fails or refuses to furnish a return or to supply information in the manner or in the time prescribed or furnishes a false or incomplete return or supplies false or incomplete information; or

(ii) Delays, obstructs or prevents an Inspector from carrying out the inspection; or

(iii) Fails or refuses, without reasonable cause to give information to an Inspector when required to do so by the Inspector, or gives false, misleading or incomplete information;

Commits an offence and is liable on conviction to imprisonment not exceeding one year or to a fine not exceeding N100,000 (One Hundred Thousand Naira).

1.5.5.3 Administrative fines

1.5.5.3.1 Without prejudice to the provisions of the Electricity Act 2023 2005 and notwithstanding the provisions of other Regulations made pursuant thereto, the Commission may impose administrative fines of not more than N10,000.00 (Ten Thousand Naira) per day, on any licensee, other undertaking or any person involved in the business of electricity generation, transmission, distribution, trading, system operation or any other aspect of the electricity supply chain, who contravenes or violates any provision of the NESIS Regulations.

1.5.5.3.2 The fine imposed shall be calculated on a daily basis and shall be in force until the violation or contravention is abated or discontinued.

1.5.5.3.3 Persistent and consistent violations or contravention of the NESIS Regulations may;

a. In the case of a licensee, lead to the suspension or removal of the licensee's management by the Commission;

b. In the case of other undertaking, lead to the Commission issuing directives to a licensee to take over operations of the undertaking.

c. In the case of electrical contractors, lead to the suspension or withdrawal of Competency Certificate(s).

1.5.6 Environmental Impact Assessment (EIA) Report

1.5.6.1 Any licensee or person engaged in the business of electricity generation, transmission, distribution, , system operation, or in any other aspect of the electricity supply chain, shall always ensure that it has an Environmental Impact Assessment (EIA) Report and Certificate from the Federal Ministry of Environment as may be required.

1.5.6.2 The EIA Certificate shall always be prominently displayed in the principal place of business of the licensee or person and shall be renewed as and when due.

1.5.7 Constitution of NESIS Review Panel

1.5.7.1 There is hereby established, a review panel to be known as the Nigerian Electricity Supply and Installation Standards (NESIS) Review Panel which shall be responsible for regular review of the Standards through consultations, research and other methodologies deemed appropriate from time to time. The activities of the Panel shall be funded by the Commission.

1.5.7.2 Constitution of the NESIS Review Panel shall be as follows:

i. Generation Companies
ii. Transmission Service Provider (TSP)
iii. Independent System Operator (ISO)
iv. Distribution Companies
v. Standard Organisation of Nigeria (SON)
vi. Representative of consumers
vii. Representative of COREN
viii. Representative of Electric Network Inspectors
ix. Representatives of State Regulatory Agencies (nominated by the Nigerian Governor's Forum).
x. Rural Electrification Agency.

1.5.7.3 The Panel shall be a standing body to carry out the functions referred to in the NESIS Regulations, and shall be maintained and funded by the Commission.

1.5.7.4 Representation of Membership

1.5.7.4.1 Composition of membership of the NESIS Review Panel shall be as follows and each of the members shall be appointed by their respective industry sector. Each member shall be COREN registered professional with adequate experience in the power sector except the two (2) legal experts;

i. Two (2) persons representing Generation Companies.
ii. One (1) person representing TSP
iii. One (1) person representing the Independent System Operator (ISO).
iv. Two (2) persons representing Distribution Companies.
v. One (1) person representing the Standards Organisation of Nigeria.
vi. One (1) person representing Customers nominated by Federal Competition and Consumer Protection Commission (FCCPC)
vii. One (1) person representing COREN.
viii. One (1) person representing NEMSA.

ix. Two (2) representatives of State Electricity Regulatory Agencies with Electrical Engineering background and nominated by Nigerian Governor's forum (NGF).
x. One (1) representing Manufacturing Association of Nigeria (MAN).

1.5.7.4.2 The Chairman, who shall be COREN registered engineer shall be elected by simple majority and Secretary of the Review Panel shall be elected by a simple majority of members present and voting.

1.5.7.5 Functions of the Review Panel

The Review Panel shall have the following functions amongst others;

i. Maintain and ensure the review of the NESIS Regulations.
ii. Review all requests for review submitted to it and propose to the Commission by way of recommendations for approval
iii. Submit to the Commission for consideration, all requests for the review and amendment of the NESIS Regulations from industry stakeholders, operators and the public.
iv. Issue guidance in the implementation, performance and interpretation of NESIS Regulations when asked to do so by the Commission, any stakeholder, operator or by a member of the public.
v. Establish and maintain joint co-ordination arrangements with any other review panel established under the Electricity Act 2023 or any Regulations, Codes, Standard made pursuant to the Electricity Act 2023 .

1.5.7.6 Amendment or Repeal of the NESIS Regulations

1.5.7.6.1 The Commission upon the recommendation of the NESIS Regulations Review Panel, can amend or repeal in whole or in part, the provisions of the NESIS Regulations.

1.5.7.6.2 The Panel may on its own or upon receipt of a request for a review of the NESIS Regulations from the respective power industry participants or members of the public through the Chairman of the NESIS Regulations Review Panel, first consider the request for a review before forwarding the request to the Commission for consideration.

1.5.7.6.3 In considering the request for a review, the Panel shall consult and expose the proposal to industry stakeholders and operators for their comments, and the Panel shall provide evidence of this consultation together with their comments to the Commission in seeking the Commission's consent for amendment.

1.5.7.6.4 Upon the consideration of the request for review and or amendment as submitted by the NESIS Regulations Review Panel and other further representations and views made in respect of the proposed amendment, the Commission shall approve the amendment as requested or in an amended form, or reject the amendment.

1.5.7.6.5 The approved amendment shall be published by the Commission.

1.5.7.6.6 Quorum at the meetings of the Panel shall be as stipulated in the Business Rules of all Technical Codes Review Panels.

1.5.8 Derogation

1.5.8.1 If a licensee or person involved in the business of electricity generation, transmission, distribution, system operation, trading or in any other aspect of the electricity supply chain, finds that it is or will be unable to comply with any of the provisions of NESIS Regulations, then such licensee, other undertaking or any person involved in the electricity supply chain, shall comply fully with the processes for seeking derogation outlined in the 'Guidelines on Derogation from Technical Codes and Standards in Electricity Generation, Transmission, Distribution and Supply In Nigeria'. " However, if such undertaking is not a licensee, it shall;

i. Without delay, report such inability to comply, to the distribution company within its area of operation and shall make such reasonable efforts as are required to remedy such non-compliance as soon as is reasonably practicable.
ii. If such an undertaking is a licensee, it shall without delay, report such inability to comply to the Commission for approval and shall make such reasonable efforts as are required to remedy such non-compliance as soon as practicable.

1.5.8.2 A request for derogation from any provisions of the NESIS Regulations shall contain;

i. The details of the equipment and connection point in respect of which derogation is sought and the nature of and extent of non-compliance;
ii. The provision of NESIS Regulation, which the licensee or person has stated, it might not be able to comply with;
iii. The reason for its inability to comply;
iv. The remedial actions and the date by which compliance could be achieved.

1.5.8.3 On receipt of any request for derogation, the Commission shall ensure that consent is not unreasonably withheld, PROVIDED that the Commission promptly considers the reasonableness of a request within thirty (30) working days of submitting all the necessary information to the Commission.

1.5.8.4 In considering a request for derogation, the Commission may contact the licensee or person for further clarification on the request, or seek further information and additional information or to discuss changes to the request, and review possible remedial actions to achieve compliance as soon as reasonably practicable.

1.5.8.5 Any request for derogation to a licensee by other undertaking, shall on application by the licensee obtain the Commission's consent after consideration of the request by the Licensee, PROVIDED that the licensee makes available to the Commission all relevant documents and information that will enable the Commission reach a reasonable decision.

1.6 Repeal of the S. I. 5: Electrical Installation Regulation and S. I. 6: Electricity Supply Regulations 1995 Issued under the Electricity Act CAP 106 LFN 1990 as amended

In accordance with Section 98(1) of the Electricity Act 2023 , S. I. 5: Electrical Installation Regulation and S. I. 6: Electricity Supply Regulation 1995 Issued under the Electricity Act CAP 106 LFN 1990 as amended are hereby repealed.

Chapter 2: Transmission Substations

2.1 Overview

These standards outline the Standard Technical Requirements for the construction of civil works and buildings for the 330/132/33 kV Transmission and Sub-transmission Substations of the National Grid of Nigeria.

a. All structures, buildings, foundations and layout shall be designed and developed in accordance with the operational, technical and functional requirements of the line and sub-station facilities.
b. All design and construction including all materials, testing and other procedures shall be undertaken in accordance with the Nigerian Electricity Supply Industry Standards Regulation.
c. All aspects of the civil works shall be designed to provide a low maintenance durable end product suitable for the purpose intended. Particular emphasis shall be placed on security of the site. Design life for structural elements shall be a minimum of 50 years.
d. The design of buildings and structures shall be in accordance with the requirements of the Nigerian Building Code (NNBC), and shall be carried out in such a manner as to ensure that construction, maintenance and demolition are carried out in a safe manner.
e. Structures shall be designed and built to an approved standard and finishing shall be aesthetically acceptable.
f. The design of the civil works and the specification of civil materials shall take into account the environmental impact of all elements. At all times, 'environmentally friendly' materials shall be incorporated into the works.
g. There shall be adequate provision made to prevent and limit fire damage including properly designed and constructed firewalls between Power Transformers. This shall be in accordance with the Nigerian Electricity Health and Safety Code.
h. This Regulation shall also be used as a guide for clearances around switchgear and other equipment. Power and control cables shall be routed and/or segregated such that minimal loss of control or supply occurs in the event of fire or damage.
i. If any object of archaeological value is found during excavation the contractor or any third party shall report such to the relevant agency.
j. This Regulation shall be read in conjunction with other relevant Regulations and Codes of Practice published by NERC.
k. In case, there are discrepancies between the requirements stipulated herein and the other Regulations and Codes of Practice, this Regulation shall prevail.
l. The requirements in this Regulation may be reviewed as new equipment become available, new technologies being developed or because of new requirements.

2.2 Civil Works

All civil works including layouts, structures, buildings, foundations, drainages and roads shall be designed and developed to provide a completely functional installation to meet technical parameters of the standards given in the following clauses:

i. Earth works to make the substation land suitable for installation of supporting structures and equipment, for erection of control building and related dependencies, with drainage to evacuate water in all conditions and of sufficient size to allow access to maintenance equipment and gravelling of switchyard surface.

ii. Fences along the perimeter of the substation for security of the installation, foundations for equipment pedestals, bus supports and gantry structures for incoming lines and strain buses.
iii. Concrete cable trenches and embedded ducts with pulling boxes and cable pits.
iv. Access roads and switchyard maintenance roads, drainage network made of perimeter trenches, switchyard internal sub soil drainage trenches or pipes.
v. Power transformers and reactors oil containment basin with oil/water separator.
vi. Substation Control building, with sanitary and water supply installations.
vii. Other related works to make a complete installation as may be required.

a. Substation construction project procedure shall include all site data gathering, analysis and engineering design necessary for the construction namely:
   i. Topographical survey
   ii. Geotechnical soil investigation
   iii. General location drawing with reference coordinates and surrounding
   iv. Drawings of earthworks
   v. Drainage system with construction details
   vi. Access road drawings
   vii. Foundation layout drawings with detailed design of each foundation including calculation brief and bill of armour rods.
   viii. Cable trench layout and details
   ix. Fences and access gate
   x. Concrete retaining wall with calculation brief and bill of armour rods
   xi. Comprehensive architectural drawings of each building and dependency showing layout, side view, finishing materials, list of main components, sanitary accessories and carpentry.
   xii. Building structure drawings with calculation brief and bill of armour rods
   xiii. Building electrical distribution diagram with bill of materials
   xiv. Sewage system with piping, septic tank, filtration pit, drainage.
b. Every project, be it a replacement, upgrade or new building, the ground shall be levelled to provide a flat and stable surface for the foundations.
c. The building shall be made in such a way as to withstand prevailing environmental situation.
d. For sites that are exposed to pollution, for example in heavily industrialized areas or exposed to salt pollution, there shall be a building to install sensitive equipment.
e. Excavation for foundations shall be made and steel reinforcement or piles installed where necessary, before casting of concrete. This forms the platform on which the equipment shall be supported or building in which the equipment shall be housed.
f. All brickwork and block work shall be of an approved standard. Internal walls shall be constructed to give a durable, low maintenance, dust free finish and shall be painted with smooth masonry paint. The final coat of paint is to be applied after installation of electrical equipment.

g. All brickwork and block work shall be laid in mortar of appropriate strength for the location and exposure of the wall, and solid walls of one brick thickness or greater to be cross bonded or tied together with stainless steel reinforcement or ties.
h. Where expansion or contraction joints are incorporated, they shall be constructed with approved joint filler and finished with appropriate sealant.
i. The building shall be designed to be as 'energy efficient' as possible while accommodating the various cables entries required.
j. Windows shall be provided for daylight conditions or ventilation in substation building and adequate mechanical ventilation shall be considered according to extant Building Regulations.
k. Emergency exit shall be provided with appropriate signage to indicate such exits.
l. Substations and switch stations shall preferably be erected above ground but where necessarily constructed underground there shall be due provision for ventilation and drainage.

2.2.1. Civil Design

a. Site location plan shall indicate the total area of the site and surrounding landscape.
b. General arrangement drawing shall include floor layout and indicating clearances between and around equipment, plant ingress/egress, emergency egress, fire segregation, cable entry and outgoing services, elevations, including doors and natural ventilation.
c. Pedestrian safety barriers shall be provided where the site layout is such that emergency egress from the substation is towards a vehicular traffic route, and that these barriers shall be required to be demountable if this were also a plant access route for the substation.
d. Foundations shall be classified in terms of shallow and deep elements and retaining structures that distribute loads from structures to the underlying soil.
e. Foundations shall be designed to maintain soil pressures at all depths within the allowable bearing capacity of the soil and must limit total and differential movements to within levels that can be tolerated by the structure.
f. Vehicular crash barrier protection shall be required external to the substation where the site layout is such that there is a risk of impact from vehicular traffic.
g. Substation design shall be such that sprinkler systems, gas, water, drainage or other third party service pipes, cables or heating and ventilation ducts are detailed within, through or under substations.
h. The design and construction shall be robust such that minimum time before maintenance is reasonably long.
i. General functional requirements such as suitable access for and cover to high and low voltage cables, security, unauthorized entry including sealed cable entries to substations containing Indoor Equipment shall be met to prevent below the ground ingress of moisture, gas and vermin.,
j. Structural steelwork shall be hot dipped galvanized, including members, internal to substation enclosures.

2.2.2. Site Preparation

a. The necessary earth cutting, filling (spreading), levelling, compaction and dressing to reach the desired formation level, backfilled earth shall be free from harmful salts; that is, Sulphates, Chlorides and any Organic or Inorganic materials and compacted to a level in accordance with the provision of the Nigerian Building Code.
b. In ensuring that a safe and hazard free high earth resistivity working area (switchyard) is observed in surfacing, and growth of weeds and grass within the working area is prevented, the following shall be duly observed:

i. Restricted distance beyond the last structure and/or equipment foundation.
ii. Thickness of base layer of lean concrete shall conform to the requirements of geological survey specifications.

c. Formation Level (FL) of substations shall be at a fixed minimum of 600mm distance higher than the surroundings on the basis of the drainage conditions and the Highest Flood Level in the area.

2.2.2.1. Earth Works

a. All foundations shall be set on undisturbed inorganic strata that provide the required minimum design for safe ground bearing capacity.
b. The bottom of excavated areas shall be trimmed, levelled or graded and well rammed or otherwise compacted.
c. The construction sequence shall be such that undue exposure of the formation level to excavations is avoided.
d. Excavations shall be kept free of all water from whatever source, and reinforced concrete foundations shall incorporate a minimum 50mm thick layer of blinding concrete.

2.2.2.2. Access Road

All plant and equipment shall be provided with sufficient free space to permit safe operation and maintenance.

a. Access to plant and apparatus shall be adequate for operational and maintenance purposes and provision shall be made for escape in the event of fire, and the escape route shall be designed to be clear of any obstructions.
b. Passageways and the minimum spacing between equipment shall be provided in accordance with the provisions of relevant safety codes, where as provision shall be made for entry of power, multicore, telephone and pilot cables, water supply and foul drainage pipes.

c. Sufficient width and depth shall be available for the cable routes such that de-rating of the cables is kept to a minimum.
d. Ducts from buildings shall normally extend a minimum distance of 500mm from the external face of the building, but if the access road is immediately adjacent to the building, then the ducts shall be continued beneath the access road to facilitate cable installation.

2.2.3. Property Block Wall Fencing

The substation shall be fenced to protect the substation personnel and equipment. Access and locking shall be in accordance with NNBC standards. The following clauses shall apply:

a. Outdoor substations and outdoor switch stations (unless the apparatus is completely enclosed in a metal casing connected with earth, the said apparatus also being connected with the system by suitable electric cables) shall be efficiently protected by fencing not less than 2.5m in height or by other means so as to prevent access to the electric lines and apparatus therein by unauthorized person(s). The said fencing, if of metal shall be earthed separately from the sub-station earth. All metallic gates shall be effectively bonded to the fencing;
b. The wall of the substation shall be labelled with an appropriate danger notice, with the name, address, and telephone number, of the licensee's local office at which an officer or servant of the licensee will be available;
c. Any metal work accessible from the ground level which normally has to be handled when the line is alive, (i.e. a switch operating handle), shall be connected to an earth mat, so situated as to include within its area the whole of the ground on which the operator would normally stand;
d. Suitable provision shall be made, either by connecting with earth a point of the system at the lower voltage or otherwise, to guard against danger by reason of the said system becoming accidentally charged above its normal voltage by leakage from or contact with the system at higher voltage.
e. Outdoor substations and outdoor switch stations shall (unless the apparatus is completely enclosed in a metal casing connected with earth, the said apparatus also being connected with the system by suitable electric cable) be enclosed within chain link or woven wire or mild steel unclimbable fencing manufactured in strict conformity with the appropriate part of the relevant Nigerian Standard not less than 2.5 m in height so as to prevent access to the electric lines and apparatus therein by unauthorized person(s).

In addition to the requirements stated above for positioning the fence with regard to touch potential and access and maintenance requirements, the security of the site shall be considered when designing the layout. The compound fence shall be inset from the boundary of the site by a minimum distance of 2m gap to prevent encroachment.

2.2.3.1. Chainlink Fencing with Gates (Vehicular/Pedestrian) shall be provided to protect the switchyard from intruders within the block wall fencing of the property.

2.2.4. Substation Control Building

Substation control building shall consist of the following:

a. Control/relay room
b. Battery room (protection and communication)

c. Telecommunication room
d. Store room
e. Personnel office
f. Meeting room
g. Toilet/bathroom
h. Kitchenette

2.2.4.1 Control/ Relay Room

a. The exact layout of the building shall depend on site requirements, including an assessment of security issues.

a. All rooms shall be appropriately segregated to meet fire protection requirements.

b. Separate external access shall normally be provided to each individual room; and there shall be no direct connecting doors between rooms. For larger sites the use of a central ‘lobby’ shall be utilised.

c. On smaller sites the requirements shall be a compact building layout with switch room, control room, battery, store and rest room. For sites with space restrictions, other optional layouts approved by NERC shall be adopted.

d. On larger sites with several rooms the provision of a central lobby shall be considered giving access to control and switch rooms. There shall still be segregation between rooms with separate entrances from the lobby area, all fitted with suitable fire doors. If convenient the rest room and kitchenette (where provided) can also be accessed from the lobby.

2.2.4.2 Control Room

a. The control room shall be designed to accommodate the following equipment as a minimum:

b. Transformer relay and AVC panels (including space for future units where appropriate)

c. Telecontrol panel and outstation

d. Mimic board (Human Machine Interface)

e. Substation battery

f. Telecontrol battery

g. Switchgear local control panel

h. Feeder and bus section relay panels as required

i. LVAC board

j. Intruder alarm panel

k. Telephone

l. Drawer filing cabinet

m. Safety notice board

n. Key cabinet / key safe

o. Fire point with extinguishers

p. Door mat – recessed type for ‘computer’ floors, otherwise standard surface mat with non-slip backing.

q. HV Insulation mat

r. Equipment shall be positioned so that there is adequate clearance for installation, inspection, maintenance and future replacement. Specific minimum distances are required to the front and rear of control and relay panels,

s. The height of the control room shall usually be the same as the adjacent switchroom, but as a minimum there shall be 1000mm clearance above the relay / control panels.

t. Suitable provision shall be made for personnel and equipment access and exit. Usually one door shall be suitable for all requirements but on some larger sites two doors may be required. The control room access door must be clearly marked, as this shall be the normal substation building entry point providing access to the intruder alarm panel.

u. Floors of control rooms shall be of reinforced concrete, or removable floor panels supported on pedestals on a concrete sub-floor. Floor panels are to have an antistatic sheet vinyl finish. A suitable skirting shall be provided around the room perimeter. Concrete floors are to be finished as stated above.

2.2.5. Equipment Plinth

a. Every foundation preparation shall include an evaluation of soil characteristics and concrete work.
b. All foundation shall be constructed of reinforced, air-entrained concrete thick with chamfered edges on top of the base and footings. In addition, to avoid problems, a civil engineer shall be consulted for guidance on the above matters.
c. In areas susceptible to seismic activities, the stability of the unit with respect to turning over shall be evaluated, whether placed outside or in a building.

2.2.6. Water Supply, Sewage & Drainage System

Water Supply & Sewage: Water supply & sewage system shall be designed to meet the total water requirement of the substations, facilities and emergency reserve for complete performance of the works. The design and construction of septic tanks and soak away pits shall have a minimum volume of $6m^3$.

2.2.7. Drainage

Where a substation or switch station is situated in any building so that a fire in the substation or switch station might involve risk to the said building and the said sub-station or switch station contains oil-immersed transformers or switches involving the use of oil in a tank, receptacle or chamber, provision shall be made for the draining away or removal of any oil which may leak or escape from the tanks, receptacles or chambers containing the same. Special precautions shall be taken to prevent the spread of any fire resulting from the ignition of the oil from any cause; and adequate provision shall be made for the extinguishing of any fire which may occur.

2.2.7.1 Design of Drainage:

For the design of drainage, the rainfall data for the site shall be obtained and the storm water drainage system including culvert, drains, and slope to accommodate the most intense rainfall that is likely to occur over the catchment area in one hour period based on an average over a period of 10 years.

2.2.7.2 Slope of Drainage System:

Invert level of drainage system at outfall point shall be decided in such a way that any water over flow from water harvesting recharge shafts can easily be discharged outside the substation boundary wall. For easy drainage of water, minimum slope of 1:1000 shall be provided from the ridge to the nearest drain. The above slope shall be provided at the top of base layer of cement concrete. The following minimum slopes & design parameters for drains shall be met:

a. Switchyard shall be sloped to prevent pounding of water and no area left un-drained;
b. Pipe drains shall be constructed on both sides of roads and open trapezoidal drains along switchyard and as per requirement in other areas;
c. Maximum spacing between two drains shall be less than 100 meter within the switchyard;
d. Open trapezoidal drains shall have 300 mm bottom width and sides slope of 1:1.5;
e. Longitudinal slope shall range from 1:1000 to 1:2000 depending upon expected discharge;
f. Side wall(s) of the drains shall be 25mm above the gravel level & covered with CI grating;
g. RCC pipe of class NP-3 (80 mm – 2600 mm) shall be used in normal pipe drains;
h. RCC pressure pipe of class NP-4 (80 mm – 2600 mm) shall be used in culverts where heavy vehicle movement is expected;
i. Pipe drains shall be connected through manholes within intervals of maximum 30 m;

2.2.8. Cable Trench

Cable trenches within enclosures housing Indoor Equipment shall have continuous reinforced concrete bottoms and reinforced concrete or filled masonry sides.

2.2.9. Gravelling

Gravel spreading shall be done in areas presently in the scope of the scheme. No stone spreading shall be done in the areas kept for future expansion (bays). To hold the stone (gravel) from spreading out of the gravel filled area, a 115mm thick and 300mm deep toe wall 25mm above top of gravel shall be provided. All visible portions of toe-wall shall be plastered and cement painted. Gravel of size 19 mm to 22 mm shall be used.

2.2.10. Landscaping

a. Any landscaping treatment around substations shall be carefully designed so as not to create potential security and safety problems.
b. Landscaping should be maintained to ensure perpetuation of design integrity and intent.
c. Successful accomplishment of this adequate landscaping shall be enhanced by the following;

i. Watering;
ii. Fertilization;
iii. Approved chemical application;
iv. Pruning and vegetation control;
v. Lawn maintenance;
vi. Plant replacement as may be required.

2.3 Electromechanical Works

2.3.1. Substation Design

a. This section details the general principles to be applied to the design of Transmission substations, including indoor and outdoor substations.
b. For substations situated in special environments, special designs for the substation shall be adopted subject to the approval of the Commission.
c. Transmission substations shall be designed to the specifications outlined in these Regulations.
d. Transmission substations shall be planned having in mind the future loading and development of the area.
e. Many of the requirements shall be associated with the safety of the operational personnel, the public and the equipment. Priority shall be given to safety, the maximum number and type of plant to be accommodated, personnel and equipment access (including power cables).

2.3.2. Equipment Layout

a. Substation equipment layout plans shall be submitted for the approval of the relevant authority.

b. Standard (or typical) substation site or layout plans submitted shall be approved by the Surveyor General or the relevant Authority.

c. Equipment shall be installed in accordance with the manufacturer's instructions.

2.3.3. Bus-bar Arrangement

a. Support structure for plant and equipment including bus-bars shall be constructed from galvanized steel, reinforced concrete or aluminium. Structures shall be designed to accommodate all normal vertical and horizontal loads plus additional loadings associated with wind and electrical fault conditions.

b. Different types of bus-bar arrangements to be employed shall be based on the voltage, reliability of the supply, flexibility in transmitting power and cost.

Table 2.3.3

Recommended Bus-bar Arrangement

S/N	Bus Description	Switching Scheme
1.	132kV	Double bus scheme or double main and transfer bus scheme
2.	330kV	Breaker and a half scheme

c. The other factors to be considered in designing the busbars arrangements shall include:

i. Simplicity in design
ii. Maintenance of different elements without interruption in the power supply
iii. Future expansion feasibility
iv. Economical in cost of installation and operation

The minimum bus-bar capacity (ampacity) for 330 kV & 132 kV sides shall be 4000 and 3000 Amps respectively.

2.3.4. Major Transmission Equipment

2.3.4.1 Transformers

a. Power Transformers:

i. 330/132 kV Transformers shall be 2-winding or auto-transformers of rating 90 - 300 MVA with 33 kV tertiary winding of 22.5 -75 MVA active capacity and On Load Tap Changer (OLTC) with + 4x1.25%/ -12x1.25% range. Vector group shall be YNy0d11 in the case of 3-winding transformers, YNd1 and YNd11 for 2-winding transformers.

ii. 132 kV / 33 kV Transformers shall be transformers of rating 30 MVA and above with On Load Tap Changer (OLTC) with +4x1.25/ -12x1.25% range. Vector group shall be YNd11.

.

b. Transformers to be used in the transmission network shall have maximum loss profile as detailed in the Table 2.3.4.1b

Table 2.3.4.1b

Recommended Allowable Transformer Losses

S. N	Description	No Load losses (KW)	Load losses (KW)	Auxiliary losses (KW)	Total Losses (KW)
1	330/132KV, 300MVA	86	482	16	584
2	330/132KV, 150MVA	43	241	10	586
3	330/132KV, 100MVA	28	233	11	272
4	330/132KV, 90MVA	28	233	11	272

c. When planning, a location shall be selected to comply with all relevant safety codes such that there shall be no interference with the normal movement of personnel, equipment, and material. The location shall not expose the transformer to possible damage from cranes, trucks, or moving equipment. Other site considerations shall require closer analysis.

d. The following shall be observed to ensure that a transformer produces the lowest possible sound level in line with the provisions of the Nigerian Electricity Health & Safety Code on noise level:

i. Connections to primary and secondary terminals shall be made with flexible connectors,

ii. All transit bolts and shipping braces are loosened so the unit shall float on rubber isolation pads,

iii. All enclosure hardware shall be tightened so panels do not vibrate.

e. Transformers shall be adequately grounded. Grounding is necessary to remove static charges that may accumulate and is required as a protection should the transformer windings accidentally come in contact with the core or enclosure (or tank for wet types).

f. All grounding or bonding systems shall meet the provisions of relevant codes and standards.

g. Power transformers and any supporting structures shall be adequately packaged and sealed against water ingress.

h. Power transformers shall conform in all respect to the highest standards of engineering design, latest revision of NIS IEC 60076, workmanship and maintainability standards relevant to the areas listed in Table 2.3.4.1h.

Table 2.3.4.1h

Recommended Transformer Standards

No.	Subject	Standard
i.	Power transformers – Part 1: General	NIS IEC 60076 – 1
ii.	Power transformers – Part 2: Temperature rise for liquid-immersed transformers	NIS IEC 60076 – 2
iii.	Power transformers – Part 3:	NIS IEC 60076 – 3

	Insulation levels, dielectric tests and external clearances in air	
iv.	Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors	NIS IEC 60076 – 4
v.	Power transformers – Part 5: Ability to withstand short circuit	NIS IEC 69976 – 5
vi.	Power transformers – Part 6: Reactors	NIS IEC 60076 – 6
vii.	Power transformers – Part 7: Loading guide for oil-immersed power transformers	NIS IEC 60076 – 7
viii.	Power transformers – Application guide	NIS IEC 60076 – 8
ix.	Power transformers – Part 10-1: Determination of sound levels – Application guide	NIS IEC 60076 – 10
x.	Power transformers – Part 13: Self-protected liquid-filled transformers	NIS IEC 60076 – 13
xi.	Power transformers – Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials	NIS IEC 60076 – 14

j. Power transformers may be overloaded during emergency up to 150% of its continuous rating in accordance with NIS IEC 60076-1 standard.

k. A power transformer tap changer (on-load) shall be suitable to compensate for system voltage variation of ±5% nominal tap position 330/132/33kV voltage ratio

l. Vector group of a three-winding power transformer shall be YN,a0,d11 in accordance with NIS IEC 60076-1, for two- winding power transformers, the vector shall be YNd11 and YNd1

m. The design of a power transformer shall take into consideration the suppression of odd harmonic voltages especially the 3rd, 5th and 7th harmonics.

n. A power transformer core shall be constructed using high grade, non-ageing, cold rolled grain oriented silicon steel laminations or superior material.

2.3.4.1.1 Mobile Transformers

Subject to relevant parts of 2.3.4.1mobile transformers must conform to the provisions of NIS IEC 60076 and shall carry all associated auxiliary equipment.

2.3.4.1.2 Earthing Transformers/Reactors

A 33kV earthing reactor will be used in conjunction with a 132/33 kV power transformer dedicated to the supply of distribution feeders. The earthing reactor will provide grounding and earth current return to the 33kV network. The 33kV earthing transformer will be used in conjunction with the 330/132/33kV autotransformers to supply the substation auxiliary service loads from the tertiary winding.

2.3.4.1.3 Capacitive Voltage Transformers (CVTs)

Capacitive Voltage Transformers (CVTs) used for instrumentation and protection of power system equipment shall conform to the following Standards: NIS/ NIS IEC60186, 60694 and 60947-1.

The number of secondary cores (protection or metering), accuracy class and burden shall be in accordance with the requirements of the protection system. The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Nigeria Metering Code.

2.3.4.1.4 Current Transformers (CTs)

Current Transformers used for instrumentation and protection of power system equipment shall conform to the following Standards: NIS/NIS IEC60186, 60694 and 60947-1.

The rated currents and ratios, the number of secondary cores (protection or metering), accuracy class, burden, secondary winding resistance, knee point voltage and excitation current shall be in accordance with the requirements of the protection system. The accuracy class for metering core shall be equal to or better than the accuracy class of the meter specified in the Nigeria Metering Code.

2.3.4.1.5 Station Service Transformers

The 33kV substation service transformers will be supplying the substation auxiliary service loads from the main substation 33kV bus-bar where available. In substations without 33kV bus-bar other means of supplying the auxiliary station loads shall be used. This includes, but not restricted to earthing transformers.

2.3.4.1.6 Combined CTs and VTs

Combined CTs and VTs shall be deployed where there is constraint of space and shall conform to the applicable standards for Current and Voltage Transformers.

2.3.4.2 Switch Gears

2.3.4.2.1 Circuit Breakers:

Interrupting medium of circuit breakers shall be SF6. Circuit breakers of 132kV and 330kV voltage class shall be suitable both for single phase and three phases auto-reclosing. Each circuit breaker shall be provided with two trip coils. Two sets of trip circuits shall be connected to separate fuse or MCB controlled DC supplies for greater reliability. The circuit breaker shall have the provision for local manual trip, which shall be placed in a position easily accessible to the operating person. Maximum rated break time in mS for circuit breakers shall be as given below in Fig 2.3.4.2.1:

Table 2.3.4.2.1

Circuit Breaker Breaking Time

Voltage (kV)	Breaking Time (mS)
330	40
132	100

The circuit breaker specifications shall be in accordance with the following NIS IEC60056, 60947-1, 60694, and 60815 standards

2.3.4.2.2 Disconnectors /Grounding Switches

Disconnect switches shall be provided as visible means of isolation. Disconnectors for 132kV and 330kV rating shall have provision for remote and manual operation. Earthing switches shall be provided at appropriate locations to facilitate earthing of outgoing Transmission lines to enable maintenance. Main blades and earth blades shall be interlocked with both electrical and mechanical means, which shall be fail-safe. Earthing switches shall be suitable for induced current switching duty as per relevant standard. Earthing switches shall be suitable for electrical and manual operation. Only local operation is recommended for earth switches.

2.3.4.2.3 Lightning Arresters

a. Every electrical equipment or any support exposed to liability or injury from lightning shall be effectively protected against such liability by lightning or surge arresters.
b. These shall be fitted with pressure relief devices and diverting ports suitable for preventing shattering of porcelain housing providing path for the flow of rated currents in the event of failure of surge arrester. A leakage current monitor with surge counter shall be provided with each lightning arrester.

All such Surge Arresters to be deployed in the NESI shall comply with the provisions of NIS IEC 60099-4 on Surge Arresters. The design and dimensions of the surge arresters shall take cognisance of the energization of the different lines as well as the lightning protection of the substation equipment.

2.3.4.3 Reactors

2.3.4.3.1 Shunt Reactors

Any shunt reactor to be deployed in the NESI shall comply with the following standards: NIS IEC 60296, 60044, 60273, 60282-2, 60289, 60529 and 60947.

2.3.4.3.2 Reactive Power Compensators

A Reactive Power Compensator if required shall be deployed to improve transmission capacity and system stability. It shall be designed, installed and commissioned in conformity with IEEE 1031-2011. When installing Reactive Power Compensators, they shall be typically placed near areas of high and rapidly varying loads.

2.3.5. Secondary Equipment

2.3.5.1 Interposing Current Transformers

All differential protection schemes shall be stabilized against all through faults and all external earth fault currents that return through the neutral of the transformer within the differential zone, and the accuracy class index shall match the instrument safety factor (ISF) of any instrument to be connected to it.

2.3.5.2 Relays

The relays to be selected shall take into consideration the expected types of failure that will be experienced and the characteristics of the failure; with the ultimate aim of causing the defective apparatus or lines to be disconnected and minimize damage and maintain service continuity to the rest of the system in accordance with NIS IEC 60255.

2.3.5.2.1 Distance Protection Relays

All transmission lines from 132kV upwards shall be protected with Distance Protection Relays as the Main or Primary protection. Any line of voltage up to 330kV shall be protected with double Main or Primary protection schemes and the applicable protective relays shall be of different makes. Where they are of the same make, they shall be of different models and must comply with NIS IEC 60255 standards.

2.3.5.2.2 Differential Relays

Differential protection schemes, as a fast unit protection shall be applicable as the Main protection for:

i. Power transformers of 5MVA and above
ii. Short Transmission lines
iii. Bus Bars

2.3.5.2.3 Over Current Relays

All substation equipment shall be protected against excessive current resulting from short circuit or earth fault by application of overcurrent relays. And the relay shall be configured to automatically isolate the faulty equipment and act as a backup protection for lines and transformers.

2.3.5.2.4 Earth Fault Relays

All transmission substation equipment, Power Transformers, Reactors, Reactive Power Compensators etc, shall be protected by an earth leakage current relay. The relay shall be set such that it is not responsive to minor out of balance current in the phases and act as back up protection for lines and transformers.

2.3.5.3 Control Panels

Control panels, including the frames to which they are attached, shall be made of fireproof material. All types of boxes, cabinets etc. shall generally conform to and be tested in accordance with NIS IEC 60439 standards, as applicable. All Control cabinets, junction boxes, Marshalling kiosks & terminal blocks shall be dust, water & vermin proof

a. No live conductor shall be exposed on the front of any control panel and the back of any control panel of which bare live metal is mounted shall be made inaccessible (except to authorized persons only) by means of earthed screens or otherwise.
b. Every door leading to the back of a control panel shall be provided with a spring or other approved device which shall ensure that the door remains open when not properly shut or locked.
c. An appropriately rated insulating mat or insulating stand shall be provided for the protection of operators in front of control panels of every control room and substation. A similar arrangement shall also be provided in the screened-in space at the rear of every control room and substation control panel (not being of the totally enclosed iron-clad cubicle type).
d. All panels shall have marked thereon, near each switch, the name of the feeder controlled by such switch.
e. All control room and substation control panels shall be provided with at least two different and independent earth connections, connected in parallel, to which all metal frames, all metal instrument cases (unless otherwise protected) and other metal parts thereof shall be connected. Means shall be provided to test the earth electrode resistance of these earth connections individually.
f. The terminal blocks shall be of extendable design, 650V category, rated to carry the maximum expected current on the terminals continuously, provided with test links and isolating facilities wherever required and suitable for connecting the designed size of conductors on each side
g. Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All inter-phase and external connections to equipment or to control cubicles will be made through terminal blocks having a locking characteristic to prevent cable disconnecting from the terminal clamp unless it is done intentionally.

2.3.5.4 Protection Panel

The fabricated protection panel shall be of adequate dimensions (height, width, and depth) to conveniently house all protective relays and auxiliary protective devices with sufficient working space.

Suitable provision shall be made, either by connecting with earth a point of the system at the lower voltage or otherwise, to guard against danger by reason of the said system becoming accidentally charged above its normal voltage by leakage from or contact with the system at the higher voltage.

2.3.5.5 Substation Automation and Protection

2.3.5.5.1 General Control Scheme

a. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from Remote Control Centre (RCC) as well as from Local Control Centre.

i. The SAS shall contain at least the following main functional parts:
a. Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
b. Station Human Machine Interface (HMI)
c. Redundant managed switched Ethernet
d. Local Area Network communication infrastructure with hot standby.
e. Peripheral equipment like printers, display units, key boards, Mouse etc.

ii. The SAS shall enable local station control via PC by means of HMI and control software package, which shall contain an extensive range of SCADA functions.

iii. The SAS shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. The communication gateway shall facilitate the information flow with remote control centers. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need for interposing components and perform control, protection, and monitoring functions.

b. All bay control units shall be connected via fibre optical cable (FOC) with SCU and the gateway computers, communicating with the latest NIS IEC protocol. For the overall interlocking within the substation, the BCUs shall communicate with each other and shall be realised on software bases within the bay control units.

c. The control hierarchy shall consist of the following levels. Provision has to be made such that if one control level is selected all other levels are blocked (priority 4-3-2-1):
i. Level 1: System control from Load Dispatch Centre (LDC)
ii. Level 2: Station control at operator's console via Station Control Unit (SCU)
iii. Level 3: Bay control with Bay Control Units (BCU)
iv. Level 4: From the switchgear mechanism box (emergency control).

d. Numerical protection relays utilising microprocessor technology including measurement processing shall be used for all kind of Main 1 and Main 2 Protection Systems.

e. All control and protection devices shall be designed to withstand the impulse voltage and high frequency interference test requirements as specified in NIS IEC 60255-5 and 60255-4.

f. The detailed application of this secondary equipment shall be as contained in the Principle of Protection in Chapter 8 of this Regulation.

2.3.5.5.2 Protection

a. All transformers 5MVA and above shall be protected by main and back up protection comprising Bucholz, Differential, Restricted Earth Fault, Overcurrent and Standby Earth Fault. The tripping contact must be wired to operate the tripping coil of the primary and secondary circuit breakers fitted adjacent to the transformers.

b. Means shall be provided at the origination of every main circuit to automatically cut off the supply of energy in the event of:
i. The passage of a current of such magnitude and duration as would be liable to damage the substation transformer, switchgears or its associated lines, joints and fittings.
ii. Leakage, of current to earth in excess of the amount permitted by these Regulations.

c. The means provided in compliance with paragraph (a) of this subsection shall be circuit breakers with appropriate nominal voltage and breaking current ratings constructed and installed in conformity with the NIS/NIS IEC standards as shall be capable of interrupting, without damage to the equipment or danger to the operator.

d. Means shall be provided to isolate the substation equipment from system short-circuit currents or fault currents likely to be handled under conditions of use to which they are subjected; and further shall similarly withstand, without damage to the equipment or danger to the operator, the currents flowing if closure is made on to a line that is, Switch-On-to-fault (SOT) or circuit which is short circuited.
e. Every Circuit Breaker shall be provided with means to show its status (closed, open) and the same indication shall be duplicated remotely on the control panel. All Circuit Breakers should be provided with two (2) disconnector switches so that it can be locked in the "OFF" position to prevent unauthorized interference. During the time that the device is locked in the "OFF" position the relevant keys for the lock shall be kept in safe custody in the manner prescribed in the Grid Code.
f. The clauses above shall be read in conjunction with the Principles of Protection contained in Chapter 8.

2.3.5.6 Substation Standby Generator(s) and Mobile Generator sockets

a. All transmission substations shall be provided with standby generators and mobile generator sockets to provide auxiliary power supply.
b. There shall be adequate interlock and protection on the auxiliary supplies to the station.

2.3.5.7 Battery Banks and Battery Chargers

a. Whenever an apparatus is supplied from secondary batteries, the work of connecting such apparatus to such batteries shall be done in accordance with the provisions of this Regulation.
b. Every battery shall be so arranged that a potential difference exceeding Fifty (50) Volts does not exist between adjacent cells without adequate protections against electrical hazard, and that each cell, the battery shall be readily accessible from the top and from at least one side.
c. In a lead-sulphuric-acid battery is having more than thirty-three cells, and in nickel-iron alkaline battery having more than fifty-three cells, shall be supported on glass or vitreous porcelain insulators. Where a battery comprises more than fifty-six lead-sulphuric-acid cells or eight nickel-iron alkaline cells the stands also shall be insulated.
d. Suitable means shall be provided for controlling the current with which battery is being charged. Such means shall comprise, as a minimum, an automatic cut-in and cut-out, or alternatively, a circuit breaker with overload and reverse-current trips.
e. Ventilation system of forced or natural means shall be maintained to prevent build up of explosive gas mixture. In which case, an alarm system shall be provided against excess gas accumulation.
f. Eye and body wash apparatus shall be provided and shall be maintained in operable condition.

2.3.5.8 Communication Equipment

Communication equipment shall be provided within the substation and between the control room and control centres, to adequately take care of the following: -

a. Voice telephony for operational purposes
b. Data-SCADA for operational purposes
c. Protection:
i. Signalling (over-reach, under reach, blocking, inter-tripping)
ii. Functionality – current differential

2.3.5.8.1 Power Line Carriers (PLC)

When building a transmission substation, communication facilities such as line matching unit (LMU), capacitive voltage transformer (CVT), Wave Traps shall be provided.

The strappings inside the LMU/ LMDU must be connected in the required manner so as to match with the impedance of the coaxial cable (75Ω /125Ω as the case may be).

2.3.5.8.2 Communication Towers and Antennas

Communication towers shall be made self-supporting not to interfere with substation conducting equipment/installations. Specification for communication towers shall conform to the provisions of the relevant Nigerian Communication Commission (NCC) Regulations.

2.3.5.8.3 Telephone Exchange

Design, construction and installation shall conform to NIS/NIS IEC standards on telephone exchange and all relevant statutory laws of Nigeria.

2.4 SCADA System and Installation

2.4.1 SCADA Control Room

SCADA Control Room shall be constructed in accordance with NIS/NIS IEC 61850 standard.

2.4.2 Remote Terminal Unit (RTUs)

Remote Terminal Unit (RTU), Phasor Measurement Unit (PMU) and Load Dispatch Centre shall comply with the relevant NIS/NIS IEC standards.

2.4.3 Communications

Communication between Intelligent Electronic Devices (IED) shall be in accordance with NIS IEC 61850 and Communication between Substation Automation System (SAS) and power plant devices shall comply with NIS IEC 60870-104.

2.5 Health, Safety and Environment

Substation construction shall comply with the provisions of the Nigerian Electricity Health and Safety Code, Regulations issued by NASREA, NEMA and other relevant authorities. Emphasis shall be given to the following areas:

a. Conveniences and Bathrooms
b. Water Supply
c. Emergency Measures

d. Disposal of Pollutants
e. Switchyard Illumination and Electrical Hazards

Chapter 3: Transmission Lines

General Provisions

The standards, as outlined herein, deal with requirements, compulsory procedures and practices necessary for overhead transmission line construction in the Nigerian Electricity Supply Industry. It is designed to meet service reliability, safe operation and maintenance of transmission lines. Such transmission lines shall be capable of withstanding expected electrical and climatic loads while maintaining design consistency between strengths of line components. **There shall be a written approval granted by NERC prior to the construction of transmission lines**. The transmission line shall be designed to meet the following fundamental requirements and shall comply with the provisions of NIS IEC 60826 standard:

i. Ensure reliable and safe power transmission capability
ii. Reduce the probability of uncontrollable propagation of failures (failure containment)
iii. Ensure safe construction and maintenance conditions

3.1 Right-of-Way

The Right of Way (RoW) is the distance of any structure from the middle conductors of overhead power lines of any voltage level. The RoW shall be as indicated in the table below.

Table 3.1

Right-of-Way

Voltage Levels	Right of Way in meters

330kV	50
132kV	30
33kV	11
11kV	11

NB: *The Right of Way measurement shall be divided equally from the centre of the line on either side. For safety reasons, no structures shall be built under the Overhead line Right of Way. Where such structures are built after the construction of the lines, the licensee shall not be liable for any mishap caused by contact with the line*.

3.2 Overhead Transmission Conductors

Conductors used for overhead transmission line construction shall be of rounded wire concentric lay stranded conductor of the form Aluminium Conductor Steel Reinforced (ACRS) and High Temperature Low Sag (HTLS) conductors such as Aluminum Conductor Composite Core (ACCC), Aluminum Conductor Steel Supported (ACSS) and Gap – type Thermal Resistance Aluminum Alloy ASCR Conductor (GAP Conductor). These HTLS conductors shall be extremely efficient and light weight compared to the conventional overhead conductors, capable of withstanding ambient temperature of 250 degree centigrade.

The properties of the conductor and appropriate cross-sectional area suitable for the designed electrical load shall be as specified in NIS IEC 61089

3.2.1 Properties of Electrical Conductors

Minimum Tensile Strength:

Overhead transmission conductors – including overhead ground wires but excluding the case where they are cables – shall be stranded wires with a tensile strength no less than 10kN/m.

Bare Conductors:

Bare conductors and overhead ground wires (including overhead ground wires containing optical fibre cables) that are used for transmission lines shall conform to the following requirements:

Properties of Solid Wires

Solid wires (hard-drawn copper wire, hard-drawn aluminium wire, galvanized steel wire, aluminium alloy wire, etc.) which compose an electrical conductor, shall have conductivity and tensile strength not lower than the values specified in the NIS IEC standards NIS IEC60028, 60889, 60888, 61232, and 60104.

i. The tensile strength of hard-drawn copper wires shall conform to Table 3.2.1.

Table 3.2.1

Diameter of solid wire (mm)	Tensile strength (N/m^2)
No less than 0.4 but no more than 12.0	No less than (462 – 10.8d)

d = Diameter of solid wire (mm)

ii. Tensile strength of stranded wire

a. Single stranded wire (electrical conductor composed of solid wires of the same kind): The tensile strength of a single stranded wire shall be the sum of the tensile strength of the solid wires.

b. Composed stranded wire with steel solid wire and other solid wires: The tensile strength of a stranded wire composed of steel solid wires and other kinds of solid wires shall be the sum of the total tensile strength of non-steel solid wires and the total tensile strength of steel wires at 1% elongation.

3.2.2 Load on Overhead Transmission Conductors and Safety Factor

a. Assumed Load and Safety Factor:

Overhead transmission conductors and overhead ground wires (excluding cables, the same applies hereafter in this section) shall be installed such that the tension shall allow for a safety factor specified in (ii) below when they are subjected to the assumed load specified in (i) below at an average ambient temperature of the test area.

i. Assumed Load: The assumed load for the calculation of tension of overhead transmission conductors and overhead ground wires shall be the composite load of the vertical loads and the horizontal loads specified as follows:

a. The vertical load shall be the weight of the electrical conductor.

b. The horizontal load shall be the horizontal wind pressure load of 790N per m^2 of vertical projected area of the electrical conductor.

ii. Safety Factor: A safety factor of no less than 2.5 shall be applied to the tensile strength (ultimate tensile strength; breaking strength) of overhead transmission conductors and overhead ground wires.

b. Prevention of Damage due to Slight Wind Oscillation: Overhead transmission conductors and overhead ground wires shall be installed so as not to suffer damage from a slight wind oscillation.

3.2.3 Jointing and Branching of Electrical Conductors

a. Jointing of Bare Conductors

Where bare conductors for overhead transmission lines are jointed with each other or with insulated conductors or cables, they shall conform to the following requirements:

i. The electric resistance of a joint shall not exceed that of a length of the used electrical conductor equal to that of the joint.

ii. The tensile strength of the electrical conductors at a joint shall not be reduced by more than 5%. However, this requirement shall not apply to cases where jumper conductors are connected and the tension applied to other electrical conductors is substantially smaller than the strength of the electrical conductors.

iii. The electrical conductors shall be jointed using jointing sleeves and other tool.

iv. Where copper conductors are jointed with aluminium conductors, bi-metal couplers or bi-metal line tap shall be used so as not to generate electrochemical corrosion in the joint.

b. Jointing of Insulated Conductors

Where insulated conductors for overhead transmission conductors are jointed with each other or with cables, they shall conform to the provisions of 3.2.3a

i. The joint shall be fully covered with material that has the same insulating effect as the insulated conductor or with a greater effect, except where the electrical conductors are jointed using a jointing kit that has the same insulating effect as the insulator of the electrical conductors or with a greater effect.
ii. Jointing of Overhead Conductors: Where overhead transmission conductors are jointed with each other, they shall conform to items (a) and (b) of Clause 3.2.3, and a junction box and other tools shall be used.

c. Jointing of Overhead Ground Wires: Overhead ground wires (including the distribution conductors of Single Wire Earth Return (SWER) systems installed at the top of a steel tower) shall be jointed in accordance with Clauses 3.2.3 (a), and (b).
d. Branching of Overhead Conductors: Overhead transmission conductors shall be branched at a supporting point of the electrical conductors except for such cases where the electrical conductors are installed so that no tension is applied to the electrical conductors at the branch point.

3.2.4 Aviation Requirements and Warning Signals:

Day and / or night visual aids and markers for denoting transmission lines or structures on flight paths in accordance with the requirements of the relevant Airspace Management Authority Regulations shall be provided on transmission towers.

3.2.5 High current carrying capacity transmission Conductor

3.2.5.1 General

High current carrying capacity transmission Conductor shall have the capability for high voltage power transmission to efficiently transmit power over long distance and withstand high temperature with minimal energy losses and improving grid stability and reliability.

3.2.5.2 High temperature low sag

HTLS conductors shall be extremely efficient and light weight compared to the conventional overhead conductors, capable of withstanding ambient temperature of 250-degree centigrade

The HTLS conductor include

i. **Aluminum Conductor Composite Core (ACCC):** Shall comprise a carbon composite core and trapezoidal shape and annealed aluminum. They can double the power transfer capacity, have lower sag at high operating temperature, result in reduced carbon emission and 20% -30 % less line loss.

Table 3.2.5.2 (i)

Code number	Cross-section	Steel wires		Conductor diameter	Linear mass			Rated tensile strength	DC resistance at 20 °C
		Number	Diameter		Aluminium	Steel	Total		
	mm^2		mm	mm	kg/km	kg/km	kg/km	kN	Ω/km
100/17	100	1	4,61	12,0	274	130	404	34,8	0,2855
125/7,5	125	1	3,09	13,5	342	59	401	28,9	0,2284
160/10	160	1	3,49	15,3	441	75	516	37	0,1798
208/28	208	7	2,25	18,3	576	217	793	66,9	0,1383
250/32	250	7	2,43	19,9	690	255	945	78,3	0,1153
300/39	300,5	7	2,67	21,8	831	307	1 139	94,4	0,0961
370/48	370,9	7	2,96	24,1	1 026	377	1 403	114	0,0777
400/52	400	7	3,07	25,1	1 104	407	1 511	121	0,0721
456/59	456	7	3,28	26,7	1 259	463	1 722	138	0,0632
505/65	505,3	7	3,45	28,1	1 395	513	1 908	153	0,0571
593/77	593,5	7	3,74	31,2	1 646	602	2 248	185	0,0488
622/153	622,5	19	3,20	34,0	1 834	1 198	3 032	276	0,0437
710/114	710	19	2,76	34,1	1 976	894	2 870	246	0,0410
731/77	731,5	19	2,27	34,0	2 032	603	2 635	210	0,0367
800/128	800	19	2,93	36,2	2 226	1 007	3 233	275	0,0363
902/74	901,9	19	2,22	36,1	2 518	579	3 097	235	0,0323
975/167	974,9	19	3,34	40,6	2 728	1 308	4 036	345	0,0300
1 000/130	1 000	19	2,95	39,8	2 779	1023	3 802	308	0,0290
1 092/89	1 092,5	19	2,44	40,6	3 046	701	3 747	280	0,0267

ii. **Aluminum Conductor Steel Supported (ACSS):** ACSS conductors shall be manufactured from annealed aluminum 1350 wires and inner high tensile strength core of galfan coated steel wires. These conductors shall be capable of operating up to 250 degrees Celsius, have low loss due to annealed aluminum and easy to install. All ACSS shall be in accordance with IEC 61089 and IEC 62219. See below table for ease of reference.

Table 3.2.5.2 (ii)

ACSS

Code Word	Size (kcmil)	Strand -ing (Al/St)	Diameter (in) Individual Wires Al	Diameter (in) Individual Wires Steel	Diameter (in) Steel Core	Diameter (in) Comp Cable	Weight (lbs/1000 ft) Al	Weight (lbs/1000 ft) Steel	Weight (lbs/1000 ft) Total	Rated Strength (lbs) Standard Strength	Rated Strength (lbs) High* Strength	Rated Strength (lbs) HS285** Strength	Resistance (OHMS/1000ft) DC @ 20°C	Resistance (OHMS/1000ft) AC @ 75°C	Ampacity @ 200°C (AMPS)
Partridge/ACSS	266.8	26/7	0.1013	0.0788	0.2363	0.642	251.3	115.5	366.8	8880	9730	11400	.0619	.0761	812
Junco/ACSS	266.8	30/7	0.0943	0.0943	0.2829	0.660	251.9	165.5	417.4	11700	13000	15200	.0615	.0756	822
Ostrich/ACSS	300.0	26/7	0.1074	0.0835	0.2506	0.680	282.6	129.9	412.5	10000	10900	12800	.0551	.0677	877
Linnet/ACSS	336.4	26/7	0.1137	0.0885	0.2654	0.720	316.8	145.7	462.5	11200	12300	14400	.0491	.0604	945
Oriole/ACSS	336.4	30/7	0.1059	0.1059	0.3177	0.741	317.6	208.7	526.3	14800	16300	19100	.0488	.0600	957
Brant/ACSS	397.5	24/7	0.1287	0.0858	0.2574	0.772	374.4	137.0	511.4	11000	12100	14100	.0417	.0514	1047
Ibis/ACSS	397.5	26/7	0.1236	0.0962	0.2885	0.783	374.4	172.1	546.5	13000	14200	16500	.0416	.0512	1054
Lark/ACSS	397.5	30/7	0.1151	0.1151	0.3453	0.806	375.3	246.5	621.8	17500	19300	22600	.0413	.0508	1068
Flicker/ACSS	447	24/7	0.1410	0.0940	0.2819	0.846	449.3	164.4	613.7	13000	14200	16400	.0348	.0429	1180
Hawk/ACSS	447	26/7	0.1354	0.1053	0.3160	0.858	449.3	206.5	655.8	15600	17100	19800	.0346	.0427	1188
Hen/ACSS	447	30/7	0.1261	0.1261	0.3783	0.883	450.4	295.9	746.3	21000	22700	26700	.0344	.0424	1204
Parakeet/ACSS	556.5	24/7	0.1523	0.1015	0.3045	0.914	524.0	192.0	716.0	15200	16600	19100	.0298	.0368	1306
Dove/ACSS	556.5	26/7	0.1463	0.1138	0.3413	0.927	524.2	240.9	765.1	18200	19900	23200	.0297	.0366	1315
Eagle/ACSS	556.5	30/7	0.1362	0.1362	0.4086	0.953	525.4	345.2	870.6	24500	26500	31100	.0295	.0363	1331
Peacock/ACSS	605	24/7	0.1588	0.1058	0.3175	0.953	569.8	208.5	778.3	16500	18100	20800	.0274	.0339	1379
Squab/ACSS	605	26/7	0.1525	0.1186	0.3559	0.966	569.8	261.9	831.7	19700	21300	25200	.0273	.0337	1389
Wood Duck/ACSS	605	30/7	0.1420	0.1420	0.4260	0.994	571.2	375.3	946.5	26000	28300	33300	.0271	.0334	1407
Teal/ACSS	605	30/19	0.1420	0.0852	0.4260	0.994	571.2	367.4	938.6	26600	29300	34800	.0272	.0335	1406
Rook/ACSS	636	24/7	0.1628	0.1085	0.3256	0.977	599.0	219.2	818.2	17300	19000	21900	.0261	.0322	1425
Grosbeak/ACSS	636	26/7	0.1564	0.1216	0.3649	0.991	599.0	275.4	874.4	20700	22400	26000	.0260	.0321	1435
Scoter/ACSS	636	30/7	0.1456	0.1456	0.4368	1.019	600.5	394.5	995.0	27400	29700	35000	.0258	.0318	1454
Egret/ACSS	636	30/19	0.1456	0.0874	0.4368	1.019	600.5	386.3	986.8	28000	30900	36600	.0258	.0319	1453
Flamingo/ACSS	666.6	24/7	0.1667	0.1111	0.3333	1.000	627.9	229.7	857.6	18200	19900	22900	.0249	.0308	1470
Gannet/ACSS	666.6	26/7	0.1601	0.1245	0.3736	1.014	627.8	288.6	916.4	21700	23400	27300	.0248	.0306	1480
Stilt/ACSS	715.5	24/7	0.1727	0.1151	0.3453	1.036	673.9	246.5	920.4	19500	21300	24600	.0232	.0287	1540
Starling/ACSS	715.5	26/7	0.1659	0.1290	0.3871	1.051	673.9	309.8	983.7	23300	25200	29800	.0231	.0286	1550
Redwing/ACSS	715.5	30/19	0.1544	0.0927	0.4633	1.081	675.6	434.6	1110.2	30800	34000	39800	.0230	.0284	1570
Cuckoo/ACSS	795	24/7	0.1820	0.1213	0.3640	1.092	748.8	274.0	1022.8	21700	23300	26900	.0209	.0259	1650
Drake/ACSS	795	26/7	0.1749	0.1360	0.4080	1.107	748.8	344.2	1093.0	25900	28000	32600	.0209	.0257	1662
Macaw/ACSS	795	42/7	0.1376	0.0764	0.2293	1.055	748.8	108.7	857.5	11800	12600	14300	.0211	.0262	1621
Tern/ACSS	795	45/7	0.1329	0.0886	0.2658	1.063	748.8	146.1	894.9	14200	15200	17400	.0210	.0263	1618
Condor/ACSS	795	54/7	0.1213	0.1213	0.3640	1.092	748.8	274.0	1022.8	21700	23300	26900	.0209	.0266	1618
Mallard/ACSS	795	30/19	0.1628	0.0977	0.4884	1.139	750.6	482.8	1233.4	34300	37900	44300	.0207	.0255	1683
Ruddy/ACSS	900	45/7	0.1414	0.0943	0.2828	1.131	847.7	165.4	1012.1	15800	17000	19200	.0186	.0233	1755
Canary/ACSS	900	54/7	0.1291	0.1291	0.3873	1.162	847.7	310.1	1157.8	24600	26400	30500	.0184	.0236	1756

ACSS

Code Word	Size (kcmil)	Strand-ing (Al/St)	Diameter (in)				Weight (lbs/1000 ft)			Rated Strength (lbs)			Resistance (OHMS/1000ft)		Ampacity @ 200°C (AMPS)
			Individual Wires		Steel Core	Comp Cable									
			Al	Steel			Al	Steel	Total	Standard Strength	High* Strength	HS285** Strength	DC @ 20°C	AC @ 75°C	
Redbird/ACSS	954	24/7	0.1994	0.1329	0.3987	1.196	898.5	328.7	1227.2	26000	28000	32300	.0174	.0217	1859
Rail/ACSS	954	45/7	0.1456	0.0971	0.2912	1.165	898.5	175.3	1073.8	16700	18000	20400	.0175	.0220	1824
Towhee/ACSS	954	48/7	0.1410	0.1097	0.3290	1.175	898.5	223.7	1122.2	19700	21300	24300	.0175	.0218	1842
Cardinal/ACSS	954	54/7	0.1329	0.1329	0.3987	1.196	898.6	328.7	1227.2	26000	28000	32300	.0174	.0223	1825
Canvasback/ACSS	954	30/19	0.1783	0.1070	0.5350	1.248	900.7	579.4	1480.1	41100	45400	53100	.0172	.0214	1897
Snowbird/ACSS	1033.5	42/7	0.1569	0.0871	0.2614	1.203	973.4	141.3	1114.7	15400	16500	18500	.0162	.0204	1924
Ortolan/ACSS	1033.5	45/7	0.1515	0.1010	0.3031	1.212	973.4	190.0	1163.4	18100	19500	22000	.0162	.0204	1921
Curlew/ACSS	1033.5	54/7	0.1383	0.1383	0.4150	1.245	973.4	356.2	1329.6	28200	30300	35000	.0161	.0206	1924
Bluejay/ACSS	1113	45/7	0.1573	0.1048	0.3145	1.258	1048.3	204.5	1252.8	19500	21100	23800	.0150	.0190	2017
Finch/ACSS	1113	54/19	0.1436	0.0861	0.4307	1.292	1053.4	375.5	1428.9	30400	33200	38700	.0150	.0193	2015
Bunting/ACSS	1192.5	45/7	0.1628	0.1085	0.3256	1.302	1123.2	219.2	1342.4	21400	23500	25400	.0140	.0178	2110
Bittern/ACSS	1272	45/7	0.1681	0.1121	0.3363	1.345	1198.0	234.0	1432.0	22300	24000	27100	.0131	.0167	2201
Pheasant/ACSS	1272	54/19	0.1535	0.0921	0.4604	1.381	1203.9	429.2	1633.1	34100	37300	43000	.0131	.0169	2200
Dipper/ACSS	1351	45/7	0.1733	0.1155	0.3465	1.386	1272.5	248.3	1520.8	23700	25500	28800	.0124	.0158	2289
Martin/ACSS	1351	54/19	0.1582	0.0949	0.4745	1.424	1278.7	455.8	1734.5	36200	39600	45600	.0123	.0160	2288
Bobolink/ACSS	1431	45/7	0.1783	0.1189	0.3566	1.427	1347.8	263.0	1610.8	25100	27000	30500	.0117	.0150	2375
Plover/ACSS	1431	54/19	0.1628	0.0977	0.4884	1.465	1354.4	482.8	1837.2	38400	41900	48300	.0117	.0151	2375
Nuthatch/ACSS	1510	45/7	0.1832	0.1221	0.3664	1.465	1422.2	277.5	1699.7	26500	28100	31800	.0111	.0143	2459
Parrot/ACSS	1510	54/19	0.1672	0.1003	0.5017	1.505	1429.2	509.5	1938.7	40400	44200	51000	.0110	.0144	2460
Ratite/ACSS	1590	42/7	0.1946	0.1081	0.3243	1.492	1497.6	217.4	1715.0	23400	25000	27900	.0105	.0136	2543
Lapwing/ACSS	1590	45/7	0.1880	0.1253	0.3759	1.504	1497.6	292.2	1789.8	27900	29600	33500	.0105	.0136	2543
Falcon/ACSS	1590	54/19	0.1716	0.1030	0.5148	1.544	1504.9	536.5	2041.4	42600	46600	53700	.0105	.0137	2545
Chukar/ACSS	1780	84/19	0.1456	0.0873	0.4367	1.601	1684.7	386.1	2070.8	35400	38200	43900	.0094	.0122	2751
Mockingbird/ACSS	2034.5	72/7	0.1681	0.1121	0.3362	1.681	1925.6	233.7	2159.3	27200	28900	32000	.0083	.0110	2960
Roadrunner/ACSS	2057	76/19	0.1645	0.0768	0.3839	1.700	1946.9	298.3	2245.2	31700	33900	38300	.0082	.0108	2992
Bluebird/ACSS	2156	84/19	0.1602	0.0961	0.4806	1.762	2040.6	467.6	2508.2	42100	45500	51700	.0078	.0103	3106
Kiwi/ACSS	2167	72/7	0.1735	0.1157	0.3470	1.735	2051.0	248.9	2299.9	29000	30800	34100	.0078	.0104	3080
Thrasher/ACSS	2312	76/19	0.1744	0.0814	0.4070	1.802	2188.2	335.3	2523.5	35600	38100	43000	.0073	.0098	3218
Joree/ACSS	2515	76/19	0.1819	0.0849	0.4245	1.880	2380.4	364.7	2745.1	38700	41400	46800	.0067	.0092	3390

Notes:
(1) Data Based on a nominal cable manufactured in accordance with ASTM B856.
(2) Resistance and Ampacity based on an aluminum conductivity of 63%, IACS at 20°C, and a steel conductivity of 8%, IACS at 20°C.
(3) Ampacity based on a 200°C conductor temperature, 25°C ambient temperature, 2ft/sec. wind, in sun, with an emissivity of 0.5 and a coefficient of solar absorption of 0.5, at sea level.
(4) Rated strength for standard strength core based on Class A Galfan coated steel core wire in accordance with ASTM B802.
(5) Rated strength for high strength core based on a Class A Galfan coated high strength steel core wire in accordance with B803.
*Designated by "/HS" (e.g. Drake/ACSS/HS)
**Designated by "/HS285" (e.g. Drake/ACSS/HS285)

iii. **Gap – type Thermal Resistance Aluminum Alloy ASCR Conductor (GAP Conductor):** Gap – type Conductor have a gap filled with heat resistant grease between the steel core and inner most layer to reduce resistance between the two layers and prevent corrosion. This allows shall allow for:

a. Tensioning the core and external layer independently to have a knee point at the installation temperature

b. Limiting the sag increase with the increase of the temperature by the thermal expansion coefficient above knee point related to the steel core
c. Maintaining the mechanical strength of the conductor with continuous operating temperature up to 210 degree Celsius

Gap – type conductors are particularly suitable to replace ACSR conductors on flat lands or in any case with small difference in level. All Gap – type concoctor shall be in accordance with IEC 60888, IEC 62004, IEC 62420 and IEC 62219.

Table 3.2.5.2 (iii)

Size		mm2	185	240	265	310	370
Equivalent conductor			Lynx	Hawk	Hen	Goose	Redwing
Stranding	(Z)TAI	No/mm	14/ TZ*1(3.23) 10/TZ(2.98)	15/ TZ(3.46) 10/TZ(3.69)	19/3.1 10/TZ(3.94)	16/3.9 10/TZ(3.94)	17/4.15 12/TZ(3.83)
	Est		7/2.0	7/2.4	7/2.8	7/2.8	7/3.8
Rated tensile strength		kN	62.4	86.8	107.5	113.8	179.5
Diameter	GTACSR/GZTACSR	mm	17.8	20.6	22.6	24.4	27.3
	Steel core		6.0	7.2	8.4	8.4	11.4
Cross sectional area	Aluminum	mm2	184.5	247.9	265.3	313.1	368.2
	Steel core		21.99	31.67	43.11	43.11	79.38
	Total		206.5	279.6	308.4	356.2	447.6
Weight	Aluminum	kg/km	700.3	955.9	1098	1227	1666
D.C.Resistance at 20˚	C	Ω/km	0.160	0.119	0.111	0.0941	0.0798
Current carrying capacity*2	GTACSR(150˚C)	A	713	863	919	1021	1147
	GZTACSR(210˚C)		871	1058	1128	1255	1414
Modulus of elasticity	GTACSR/GZTACSR	GPa	77.1	78.1	81.9	79.2	87.4
	Steel core		205.9	205.9	205.9	205.9	205.9
Coefficient of linear expansion	GTACSR	10-6/˚C	19.7	19.6	19.0	19.4	18.2
	Steel core		11.5	11.5	11.5	11.5	11.5

Size		mm2	410	413	520	620
Equivalent conductor			Condor	Drake	-	-
Stranding	(Z)TAI	No/mm	15/4.6 10/TZ(4.55)	16/4.4 10/TZ(4.65)	18/TZ(4.01) 14/TZ(3.96) 10/TZ(3.88)	16/TZ(4.80) 12/TZ(4.75) 12/TZ(3.47)
	Est		7/3.0	7/3.2	7/3.0	7/3.2
Rated Tensile Strengt	h	kN	138.1	149.2	152.9	178.3
Diameter	GTACSR/GZTACSR	mm	27.6	27.8	29.0	31.5

	Steel core		9.0	9.6	9.0	9.6
Cross sectional area	Aluminum	mm2	411.9	413.2	518.0	615.7
	Steel core		49.48	56.29	49.48	56.29
	Total		461.4	469.5	567.5	672.0
Weight	Aluminum	kg/km	1557	1616	1856	2179
D.C.Resistance at 20˚	C	Ω/km	0.0714	0.0714	0.0570	0.0478
Current carrying capacity*2	GTACSR(150˚C)	A	1257	1219	1356	1516
	GZTACSR(210˚C)		1500	1503	1667	1866
Modulus of elasticity	GTACSR/GZTACSR	GPa	77.3	79.1	74.4	73.5
	Steel core		205.9	205.9	205.9	205.9
Coefficient of linear expansion	GTACSR	10-6/˚C	19.7	19.4	20.2	20.3
	Steel core		11.5	11.5	11.5	11.5

3.2.5.3 Cover cables for Transmission Lines

A standard for cover cable includes area bunch cables, spacer cable system, polyethylene cables and cross – linked polyethylene cables (XLPE Cables)

i. **XLPE cable:** Cross – linked polyethylene serves as the primary insulating materials in XLPE cables, which can withstand greater temperature under both normal loads and short circuit circumstances. All XLPE cable shall be in accordance with IEC60840 for a system voltage range of 30 – 150kV and IEC 62067 for range of 150 – 500KV
ii. **Spacer cables:** Is a type of overhead power transmission line technology which incorporate spacers or insulating devices to separate the conductors allowing them to be placed together without compromising safety. These cables are designed to enhance the overall performance of power transmission line by increasing efficiency and capacity and shall be in accordance with IEC61196 – 12 (2024), IEC 61854, and IEC 61284

3.2.5.4 Smart Cables

Smart cables shall be used for the incorporation of sensors and communication technologies into power and control lines. These cables shall have built in health and performance monitoring to instantly identify problems such as damages and overheating in line with IEC 61850, IEC 61970, IEC 62443, and IEC 60870 (5 – 104)

3.3 Insulator for Overhead Transmission Lines

3.3.1 Mechanical Strength of Insulators for Overhead Transmission Lines

a. Assumed Load

The assumed loads to be used for calculating the strength of insulator devices for overhead transmission lines shall conform to the following requirements:

i. Vertical Load: The vertical load shall be the sum of the weight of electrical conductors, the weight of insulator devices and the vertical component of force generated by the assumed maximum tension of the electrical conductors.

ii. Horizontal Transverse Load: The horizontal transverse load shall be the sum of the wind pressure loads of electrical conductors and insulator devices and the horizontal component of load generated by the assumed maximum tension of the electrical conductors. The wind pressure loads shall be calculated based on the values listed in Table 3.3.1a

Table 3.3.1a

Wind Pressure

Subject to wind pressure		Wind pressure on vertical projected area (N/m^2)
Electrical	Multiple conductor *	710
	Single conductors	790
Insulator device		1100

** This applies only to cases where two compositional conductors are arranged horizontally and the distance between such electrical conductors is no more than twenty times their outer diameter.*

iii. Assumed Maximum Tension of Transmission Conductors: The assumed maximum tension of the transmission conductor under the composite load of the vertical load generated by the weight of the electrical conductor and the horizontal load generated by the horizontal wind pressure stipulated in Table 3.3.1a at the average temperature in the area.

b. Safety Factor: A safety factor of no less than 2.5 shall be applied to the insulator devices for overhead transmission lines. The safety factor mentioned above shall be obtained as follows:

i. Tension insulator device (Insulator device that anchors electrical conductors).

$$\textit{Safety Factor} = \frac{\textit{Tensile Break Strength}}{\textit{Assumed Maximum Tension at Support Point}}$$

ii. Suspension insulator device (Insulator device that electrical conductors are hung from).

$$\textit{Safety Factor} = \frac{\textit{Tensile Break Strength}}{\substack{\textit{Composite Load of Transverse Load} \\ \textit{and Horizontal Transverse Load}}}$$

iii. Supporting insulator device

$$Safety\ Factor = \frac{Bending\ Break\ Strength}{\begin{array}{c}Horizontal\ Transverse\ Load\ or\ Vertical\ Load\\ Applied\ perpendicular\ to\ axis\ of\ insulator\ Device\end{array}}$$

3.4 Dielectric Strength of Overhead Transmission Lines

3.4.1 Clearance between Supporting Structures and Electrical Conductors

The clearance between overhead transmission conductors (excluding cables) and their supporting structures, cross arms or guys (pole braces) shall not be less than the values shown in Table 3.4.1 even when the electrical conductor sways by a wind velocity of about 20m/s.

Table 3.4.1

Clearance of Support Structures and Electrical Conductors

Nominal Voltage	Clearance
132kV	No less than 70cm
330kV	No less than 145cm

*As per subsection 5.1.5.7.3 (Support Structures for Distribution Lines)

3.4.2 Dielectric Strength of Overhead Transmission Lines

a. Dielectric Strength of Insulators
The insulators to be used for overhead transmission lines shall have the dielectric strength that has been verified in the wet power-frequency voltage test specified in NIS IEC60383-1 or other equivalent NIS IEC tests.

b. Dielectric Strength Test
Where the operational voltage to ground is applied between the overhead transmission line and the ground continuously for ten (10) minutes to test the dielectric strength (in conformity with NIS IEC60038) before the commencement of operation, the transmission line shall withstand such a test standard.

c. In case where cables are used for overhead transmission lines, the test shall conform to subsection 3.8.1.1.

3.5 Supporting Structures

3.5.1 Steel Structural Members of Supporting Structures

a. Fundamental Properties
Flat steel, shaped steel, steel pipes, steel plates, steel bars and bolts which compose a steel tower or iron pole used for overhead transmission lines shall be appropriate ones as specified by ISO and SON.

b. Thickness of Steel Members
Shaped steel, steel pipes and steel plates to be used for steel tower or iron pole for overhead transmission lines shall have the thickness and other dimensions specified below:

i. Minimum thickness of shaped steel to be used as:

a. Main post member of an iron pole (in which a main member of a cross arm is included; the same shall apply hereafter in this section) shall have the thickness of 4mm.

b. Main post member of a steel tower shall have the thickness of 5mm.

c. Other structural members shall have the thickness of 3mm.

ii. Minimum thickness of steel pipes to be used as:

a. Main post member of an iron pole shall have the thickness of 2mm.

b. Main post member of a steel tower shall have the thickness of 2.4mm.

c. Other structural members shall have the thickness of 1.6mm.

iii. Slenderness ratio of steel members

The slenderness ratio of a compression member shall be no more than 200 for those to be used as a main post member and no more than 220 for compression members other than main post members (excluding those used as auxiliary members) and no more than 250 for those used as auxiliary members.

iv. Minimum thickness of steel plates

The thickness shall be no less than 1mm.

c. Strength of Steel Members and Bolts

Steel members and bolts to be used for a steel tower or an iron pole of overhead transmission lines shall have the strength as specified in Table 3.5.1(a)

Table 3.5.1(a)

Classification of strength		**Strength**
Tensile strength	When $\sigma_Y \leqq 0.7\sigma_B$	σ_Y
	When $\sigma_Y > 0.7\sigma_B$	$0.7\sigma_B$
Compression strength		σ_Y
Flexural strength		σ_Y
Shearing strength	When $\sigma_Y \leqq 0.7\sigma_B$	$\sigma_Y / \sqrt{3}$
	When $\sigma_Y > 0.7\sigma_B$	$0.7\sigma_B / \sqrt{3}$
Bearing strength		$1.65\sigma_Y$
Buckling strength	$0 < \lambda_k < \Lambda$	$\sigma_Y[K_0 - K_1\{\lambda_k/(\pi/\sqrt{(E/\sigma_Y)})\} - K_2\{\lambda_k/(\pi/\sqrt{(E/\sigma_Y)})\}^2]$
	$\Lambda \leqq \lambda_k$	$1.5\pi^2E / 2.2\lambda_k^2$

Where

σ_Y: Yield point strength of steel members and bolts

σ_B: Tensile strength of steel members and bolts

λ_k: Effective slenderness ratio ($= L_k / r$)

L_k: Effective buckling length of steel members

r: Turning radius of a steel member cross-section

E: Elastic modulus (20.6×10^2 N/m^2)

Λ: π

K, K_0, K_1, K_2: Refer to Table 3.5.1 (b)

Table 3.5.1 (b)

	K	K_0	K_1	K_2
Structural members with little decentring (steel pipe, cruciform, section plate, etc.)	0.6	1	0	0.352
Structural members with a little decentring (angle steel used for a main post member, etc.)	0.5	0.945	0.0123	0.316
Structural members with significant decentring (angle steel used for a web member with one side flange joint, etc.) (*)	0.3	0.939	0.424	0

** Note that the buckling strength shall be no more than $0.6\sigma_Y$ for structural members with significant decentring.*

d. Strength of Reinforced Concrete Pole Components
Components of a reinforced concrete pole for overhead transmission lines shall have the strength as specified below:

i. Strength of concrete: The strength of concrete at yield point shall be based on the design standard strength (4-week strength; F_c) of concrete and conform to Table 3.5.1 (c).)

Table 3.5.1(c)

Compression strength [$\times 10^6 N/m^2$]	$F_c/2$
Tensile strength [$\times 10^6 N/m^2$]	$F_c/20$
Shearing strength [$\times 10^6 N/m^2$]	$F_c/20$ and $0.74+1.5F_c/100$

ii. Bond strength of concrete: The bond strength of concrete at yield point shall be based on the design standard strength (4-week strength; Fc) and conform to Table 3.5.1(d)

Table 3.5.1(d)

	Bending monitor [$\times 10^6 N/m^2$]		Fixative joint
	Upper edge round bar	Normal round bar	
Round	$6F_c/100$ and no more than 1.32	$9F_c/100$ and no more than 1.99	$6F_c/100$ and no more than 1.32
Deformed	$F_c/10$ and no more than $1.32+3F_c/75$	$3F_c/20$ and no more than $99+3F_c/50$	$F_c/10$ and no more than $1.32+3F_c/75$
Shaped			$3F_c/100$ and no more than 0.66

iii. Strength of shaped steel, flat steel and steel bars: The strength of shaped steel, flat steel, and steel bars at yield point shall conform to Table 3.5.1(e)

Table 3.5.1(e)

		Yield tensile strength (N/mm^2)	Yield compression strength (N/mm^2)
Tubular bar		σ_Y and no more than 234	σ_Y and no more than 234
Deformed tubular	Diameter ≧ 29mm	σ_Y and no more than 294	σ_Y and no more than 294
	29mm > Diameter > 25mm	σ_Y	σ_Y
	25mm ≧ Diameter	σ_Y and no more than 322	σ_Y and no more than 322
Others		σ_Y and no more than 0.7σB	σ_Y

σ_Y: Strength of material at yield point
σ_B: Tensile strength of material

iv. Strength of bolts: The strength of bolts shall conform to Table 3.5.1(a).

3.5.2 Loads on Supporting Structures and Safety Factor

3.5.2. 1 Types and Combinations of Assumed Loads

Types and combinations of assumed loads to be used for calculating the strength of supporting structures for overhead transmission lines shall conform to the following provisions:

a. The loads specified in Table 3.5.2.1(a) shall be used in the combinations shown in Table 3.5.2.1(b) depending on the classification and type of supporting structure.

Table 3.5.2.1(a)

Type of Load	Contents	Symbol
Vertical load	The load applied by the weight of the supporting structure (including cross arms)	Wt
	The load applied by the weight of strung wires and insulating devices If the electrical line has a remarkable vertical angle, the vertical load from the line shall be added	Wc
	If guys are used (in case of a steel tower, this shall be limited to a temporary electrical line specified in Paragraph 2 in Article 107), the load by a vertical component of force generated by tension of the guys shall be added.	Ws
Horizontal transverse load	Wind pressure load applied to the supporting structure (including cross arms)	Ht
	Wind pressure load applied to strung wires and insulator devices	Hc
	The load by horizontal transverse component of force generated by the assumed maximum tension of strung wires when the electrical line has a horizontal angle	Ha
	The load by a torsional force stress generated by cutting strung wires	Q
Horizontal longitudinal load	Wind pressure load applied to the supporting structure (including cross arms)	H_t
	The load by a horizontal longitudinal component of unbalanced tension of strung wires	P_1
	The load by a horizontal longitudinal component of unbalanced tension generated by cutting strung wires	P_2
	The load by a torsional force stress generated by cutting strung wires	Q_1

Where strung wires mean electrical conductors and overhead ground wires. The same applies hereafter in this Regulation.

Table 3.5.2.1(b)

Classification of supporting structure	***Type of supporting structure***	***Load condition***	***Wind direction***	***Combination of assumed loads***										
				Vertical load			***Horizontal transverse load***				***Horizontal longitudinal load***			
				Wt	***Wc***	***Ws***	***Ht***	***Hc***	***Ha***	***q***	***H't***	***P1***	***P2***	***q1***
Class A reinforced concrete pole	All types	Wind pressure load	Perpendicular to the electrical line				o	o						
			Parallel to the electrical line				o							
Class A iron pole	All types	Wind pressure load and vertical load	Perpendicular to the electrical line	o	o	o	o	o						
			Parallel to the electrical line	o	o	o	o							
Class B reinforced concrete pole Class B iron pole	Common type	Assumed normal load	Perpendicular to the electrical line	o	o	o	o	o	o					
			Parallel to the electrical line	o	o	o			o		o			
	Anchor type	Assumed normal load	Perpendicular to the electrical line	o	o	o	o	o				o		
			Parallel to the electrical line	o	o	o					o	o		
	Strain type	Assumed normal load	Perpendicular to the electrical line	o	o	o	o	o	o			o		
			Parallel to the electrical line	o	o	o					o	o		
Steel tower	Common type	Assumed normal load	Perpendicular to the electrical line	o	o	o	o	o	o					
			Parallel to the electrical line	o	o	o			o		o			
		Assumed abnormal load	Perpendicular to the electrical line	o	o	o	o	o	o	o			o	o
			Parallel to the electrical line	o	o	o			o	o	o		o	o
	Anchor type	Assumed normal load	Perpendicular to the electrical line	o	o	o	o	o				o		
			Parallel to the electrical line	o	o	o					o	o		
		Assumed abnormal load	Perpendicular to the electrical line	o	o	o	o	o		o		o		o
			Parallel to the electrical line	o	o	o				o	o	o		o
	Strain type	Assumed normal load	Perpendicular to the electrical line	o	o	o	o	o				o		
			Parallel to the electrical line	o	o	o					o	o		
		Assumed abnormal load	Perpendicular to the electrical line	o	o	o	o	o		o			o	o
			Parallel to the electrical line	o	o	o				o	o		o	o

Note*: Circles o indicate the assumed loads to be considered at the same time. The wind direction that brings the bigger assumed load should be selected.*

The supporting structures in Table 3.5.2.1(b) shall have the following types:

i. Anchor type: Supporting the structure for use of anchoring all strung wires

ii. Strain type: Supporting structure for use of reinforcing the linear parts of electrical lines or use in a place where there is a large difference in the span at both sides of the supporting structure

iii. Common type: Supporting Structures, excluding (i) and (ii) above, with tension type or suspension type insulator devices

b. Where strung wires are arranged asymmetrically on the supporting structure, the assumed vertical eccentric load shall be added to the load in Table 4.2.1(b), and the load by normal torsional load shall also be added for anchor or strain type.

3.5.2. 2 Wind Pressure Load

a. Wind Pressure Values
The wind pressure load used for subsection 3.5.2.1(b) shall be the value obtained by calculation based on the wind pressure specified in Table 3.5.2.2(a)

i. This shall not apply when calculation is made based on values obtained by a wind pressure (wind duct) test using a wind at a velocity of not less than 35m/s.

ii. The wind receiving area shall be the vertical projected area of the structural member. For cross arms of a concrete pole, an iron pole except a column pole, and steel tower, the wind receiving area shall be the vertical projected area of the front structures that receive the wind.

Table 3.5.2.2(a)

Subject to the wind pressure			Wind pressure to $1m^3$ of the vertical projected area of the structural member (N)
Supporting	Iron pole	Columnar pole	630

structure		Triangle or rhombic pole		1500
		Square pole consisting of steel pipes		1180
		Others		1740 when the web members overlap in the front and the back
				1890 in other cases
	Reinforced concrete pole	Columnar pole		630
		Others		950
	Steel tower	Shaped steel tower		2290
		Steel pipe tower		1350
		Single pole	Columnar pole	630
			Hexagonal or octagonal pole	1180
Electrical conductors and other strung wires	Electrical wires forming multiple conductors (Limited to those in which two compositional conductors are arranged horizontally and the distance between such electrical conductors is no more than 20 times their outer diameter)			710
	Others			790
Insulator device				1100
Cross arms for an iron pole (limited to a columnar pole) and a reinforced concrete pole				1260 when it is used as a single member
				1740 other cases

b. Wind pressure load at an oblique wind

When the wind blows to the electrical line at an angle of 60°, the wind pressure load in an assumed normal load of a common type steel tower shall be that calculated by the wind power pressure load multiplier (in case of a square tower) in Table 3.5.2.2(b)

Table 3.5.2.2(b)

Classification of wind pressure load			**The multiplier to the wind pressure load when the wind blows perpendicular to the electrical line (in case of a square tower)**
Wind pressure load to steel tower	Wind pressure load to body	Shaped steel tower	1.6
		Steel pipe tower	1.4
	Wind pressure load to cross arm		0.5 (for the wind pressure in the direction of the electrical line)
Wind pressure load to strung wire			0.75

c. Augmentation of wind pressure by the height

i. Steel tower: The wind pressure of a shaped steel tower or steel pipe tower that is higher than 40m shall conform to Table 3.5.2.2(c)

Table 3.5.2.2(c)

Height	Shaped steel tower		Steel pipe tower	
	Below 330kV	No less than 330kV	Below 330kV	No less than 330kV
No higher than 50m	2,450	2,610	1,430	1,500

No higher than 60m	2,610	2,760	1,500	1,580
No higher than 70m	-	2,920	-	1,660
No higher than 80m	-	3,080	-	1,740

ii. Wires and insulators: When a steel tower is higher than 80m, the wind pressure shall be calculated by increasing the wind velocity appropriately.

3.5.2. 3 Unbalanced Tension

Unbalanced tension used Clause 3.5.2.1 shall conform to the following requirements:

a. The unbalanced tension and the torsional force shall conform to Table 3.5.2.3

Table 3.5.2.3

Classification of supporting structure	***Type of supporting structure***	***Unbalanced tension and torsional force***	
		Assumed normal load	***Assumed abnormal load***
Steel tower	Common type	No specification	Horizontal longitudinal component of force of the unbalanced tension generated by cutting strung wires and torsional force
	Anchor type	Horizontal longitudinal component of force of the unbalanced tension equal to the assumed maximum tension for each strung wire	
	Strain type	Horizontal longitudinal component of force of the unbalanced tension equal to 1/3 of the assumed maximum tension for each strung wire	
Class B iron reinforced concrete pole and concrete pole and Class B iron pole	Common type	No specification	No specification
	Anchor type	Horizontal longitudinal component of force of the unbalanced tension equal to the assumed maximum tension for each strung wire	
	Strain type	Horizontal longitudinal component of force of the unbalanced tension equal to 1/3 of the assumed maximum tension for each strung wire	

3.5.2. 4 Safety Factor of Supporting Structure

The yield strength of the structural members of reinforced concrete poles, iron poles and steel towers used for overhead transmission lines shall satisfy the safety factor listed in Table 3.5.2.4 for the assumed loads specified in clauses 3.5.2.1 to 3.5.2.3.

Table 3.5.2.4

Classification of supporting structure	**Load condition**	**Safety factor**
Class A reinforced concrete pole	Wind pressure load	1.65
Class A iron pole	Wind pressure load Vertical load	1.65
Class B reinforced concrete pole Class B iron pole	Assumed normal load	1.65
Steel tower	Assumed normal load	1.65

	Assumed abnormal load	1.1 (1.65 for cross arms)

3.5.3 Loads on Foundations of Supporting Structures and Safety Factor

3.5.3. 1 Loads on the Foundation of a Supporting Structure

The loads applied to the foundation of a supporting structure for overhead transmission lines shall be calculated from combinations of assumed loads of the supporting structure specified in the Clause 3.5.2 and the resultant maximum values shall be the assumed normal and abnormal loads for the foundation.

3.5.3. 2 Safety Factor of the Foundation

The safety factor of the foundation of a supporting structure for overhead transmission lines shall satisfy the value listed in Table 3.5.3.2 for its yield strength.

Table 3.5.3.2

Classification of supporting structure	*Safety factor*	
	Assumed normal load	*Assumed abnormal load*
Reinforced concrete pole and iron pole	2.0	3.0
Steel tower	2.0	2.5

3.5.3. 3 Treatment of the Weight of the Foundation

The weight of the foundation used for calculating the safety factor shall be treated in accordance with the following provisions:

a. For the foundation subject to a lifting load, two thirds or less of the weight of the foundation (or weight of the foundation of a steel tower to an abnormal load) may be included in the lift bearing power.

b. For the foundation subject to a compressive load, the weight of the foundation shall be included in the compressive load.

3.5.4 Reinforcement of Overhead Transmission Lines

3.5.4.1 Class A Reinforced Concrete Poles and Class A iron poles

Where five or more Class A reinforced concrete poles or Class A iron poles used for overhead transmission lines are installed successfully in a straight portion (including portions with a horizontal angle of five degrees or less), such poles shall be installed according to the following requirements:

a. For every five poles or less frequently, guys shall be installed on both sides of wires in the direction perpendicular to the electrical line. The same shall not apply when voltage of 33kV or below is used.

b. Where 15 or more of such poles are successive, guys shall be installed on both sides of wires in the direction of the electrical line for every 15 poles or less.

c. The guys installed according to 3.5.4.1 (a) and 3.5.4.1 (b) can be used in common with the guys installed according to the provisions of Clause 3.5.4.4.

3.5.4.2 Class B Reinforced Concrete Poles or Class B Iron poles

Where ten or more Class B reinforced poles and Class B iron poles with suspension insulator devices are used successively, one iron reinforced concrete pole or iron pole of strain type shall be installed for every ten poles or less frequently.

3.5.4.3 Steel Tower

Where ten or more steel towers with suspension insulator devices are used successively, one steel tower with a strain-type suspension insulator or one steel tower with suspension insulator device shall be used for every ten towers or less frequently. Such a suspension insulator device shall be designed assuming that the magnitude of unbalanced tension generated by cutting a strung wire is the value equal to the assumed maximum tension of the strung wire when the assumed abnormal load is determined.

3.5.4.4 Reinforcement by Guys

a. Guys for Class A reinforced poles, Class A iron poles, Class B reinforced concrete poles and Class B iron poles used for overhead transmission lines shall be installed according to:

i. Supporting structures other than steel towers may be guyed to share strength with the guys. In such a case, the strength of the supporting structure itself shall be such that it endures a half or more of the wind load.

ii. In a straight section ("Straight section" includes such a portion that forms a horizontal angle of 5 degrees or less) using 15 or more consecutive Class A poles ("Class A Poles" includes Class A iron poles and Class A reinforced concrete poles.), guys shall be installed on both sides of the distribution line at intervals of 15 poles or less.

b. Steels towers used for overhead transmission lines shall have no guys that share the strength of the towers. However, steel towers to be used temporarily within six months may be equipped with guys. In this case, the guys shall be installed according to Clause 3.5.4.4(a)(i)

c. Guys used for reinforced concrete poles, iron poles and steel towers shall conform to:

i. Upper part of the guy

The metallic wire used for the guy shall be as follows:

(a) The safety factor shall be 2.6 or over (The safety factor shall be 1.5 or over for a guy installed with a wooden pole, iron pole Class A or reinforced concrete pole Class A).

(b) If a twisted conductor is used for the metallic wire, it shall have 3 or more strands and a minimum tensile strength of 10 kN or over.

ii. Portion near the ground

For the portion near the ground, that is, from the underground portion of the guy installed with a reinforced concrete pole or iron pole to 30 cm above the ground, a galvanized iron rod or similar rod equal or superior to it in strength and corrosion resistance shall be used.

iii. Foundation

The guy anchor shall be installed firmly so that it can adequately endure the tensile load from the guy. A guy anchor installed with a supporting structure other than a wooden pole shall be of such a material that hardly corrodes.

iv. Others

(a) If a guy installed on an overhead transmission or distribution line is in danger of touching an electrical conductor, an insulator or the like shall be inserted in the upper part of the guy.

However, an insulator or the like need not be inserted if the guy is installed on a low-voltage overhead distribution line in a place other than a rice field or other swamp.

(b) A guy crossing a road shall have a height of 5 m or over from the road surface.

If this is impossible for technical reasons, 4.5 m or over and 2.5 m or over above a sidewalk are allowed when there is no danger of interfering with traffic.

3.6 Regulations for Installation

3.6.1 Clearance between Overhead Ground Wires and Electrical Conductors

Where electric circuits cross at mid-span positions, the following conditions shall apply-

a. The circuit of the higher voltage shall always cross over the circuit of the lower voltage;

b. No circuit shall cross at an angle of less than 30 degrees; and

c. The minimum clearance between the nearest conductors of different circuits at the point of crossing, including "aerial" earth wire, shall not be less than that tabulated below PLUS the maximum design sag of the conductor of the lower circuit at the point of crossing.

Table 3.6.1

Lower Circuit (Voltage between phases)					***Upper Circuit (Voltage between phases)***				
	Earth wire	**400 (415)**	**3,300**	**6,600**	**11,000**	**33,000**	**66,000**	**132,000**	**330,000**
Convert to Metres (m)	*(cm)*	*(cm)*	*(cm)*	*(cm)*	*(cm)*	*(cm)*	*(cm)*	*(cm)*	*(cm)*
Earth wire	30	20	30	30	30	120	60	120	240
400 (415) V	20	120	120	120	120	120	150	180	270

3,300V	30	—	—	120	120	120	150	180	270
6,600V	30	—	—	120	120	120	150	180	270
11,000V	30	—	—	—	120	—	150	180	270
33,000V	30	—	—	—	—	—	150	180	270
66,000V	60	—	—	—	—	—	150	210	300
132,000V	120	—	—	—	—	—	—	240	360
330,000V	240	—	—	—	—	—	—	—	480

Where the circuit of the higher voltage is fully insulated the minimum clearance calculated in accordance with 3.5.1c above may be reduced by 50%.

3.6.2 Height of Overhead Transmission Conductors and Limitation of Span

a. The height above ground of any electric line under the most adverse operating conditions shall not, except with the written authority of NERC, be less than the height appropriate to the system voltage and situations tabulated in Table 3.6.2 below.

b. Fully insulated service lines operating at a voltage not exceeding 400Volts may be terminated on buildings at a height of not less than 2.7 m from ground level provided that the street clearance at any point of its span is not less than 5.8 m.

Table 3.6.2

Ground clearance in (m)			
System voltage between phases	**Over streets and roads and public open spaces and other places of vehicular traffic**	**Along streets and roads and other places accessible to traffic**	**In positions inaccessible to vehicular traffic not streets or roads**
415Volts	5.8 m	5.2 m	5.2 m
3,300 Volts	5.8 m	5.5 m	5.5 m
6,600 Volts	5.8 m	5.5 m	5.5 m
11,000 Volts	5.8 m	5.5 m	5.5 m
33,000 Volts	6.0 m	6.0 m	5.8 m
66,000 Volts	7.0 m	7.0 m	5.8 m
132,000 Volts	7.0 m	7.0 m	5.8 m
330,000 Volts	7.0 m	7.0 m	5.8 m

3.6.3 Clearance between Plants and Overhead Transmission Conductors

The clearance between any overhead transmission conductor and any plant shall not be less than the value specified in the Table 3.6.3 below. The clearance shall be secured to provide for the occurrence of such case that the electrical conductor dips at the maximum design operating temperature or sways in the wind.

Table 3.6.3

Nominal voltage	Vertical Clearance
No higher than 33 kV	2 m
Higher than 33 kV	The value obtained by adding 6 cm for every 10 kV and fraction thereof over 33 kV to 2 m

This shall not apply when overhead transmission lines are installed according to the following requirements:

a. Overhead transmission conductors with a voltage not higher than 33 kV, for which insulated conductors are used, shall be installed so as not to contact plants.

b. Overhead transmission conductors with a voltage not higher than 132 kV, for which cables are used, shall be installed so as not to make contact with plants.

3.6.4 Restrictions in Urban Areas

No overhead transmission line shall be installed in urban areas or other densely populated and built-up areas.

The restrictions above shall not apply where the nominal voltage of the overhead transmission line is not more than 132kV and the electrical conductors are cables or the installation is carried out according to the following requirements:

a. Strength of electrical conductor
The strength of electrical conductor shall conform to Table 3.6.4(a).

Table 3.6.4(a)

Nominal voltage	Strength of electrical conductor
No higher than 33kV	Stranded wire with a tensile strength no less than 30kN
Higher than 33kV but no higher than 132kV	Stranded wire with a tensile strength no less than 40kN

b. Limitation of Span
The length of span of overhead transmission lines shall conform to Table 3.6.4(b).

Table 3.6.4(b)

Classification of supporting	Length of Span

structure	
Class A reinforced concrete pole or class A iron pole	No longer than 75 m
Class B reinforced concrete pole or class B iron pole	No longer than 150 m
Steel tower	No longer than 400 m (or no longer than 250m when two or more electrical conductors are arranged horizontally and the distance between the electrical conductors is less than 4 m)

c. Height of electrical conductor above the ground

The height of overhead transmission conductors above the ground shall be not less than the value specified in Table 3.6.4(c) below. The height shall be secured to provide for the occurrence of such case that the electrical conductor sag at the maximum design operating temperature.

This shall not apply to overhead transmission lines for a span connecting the yard of a power plant, substation or similar place to the outside.

Table 3.6.4(c)

Nominal voltage	Height of electrical conductor above the ground
Not higher than 33kV	10.06 m (8 m when insulated conductors are used)
Higher than 33kV	Value obtained by adding 6 cm for each 10kV over 33kV and fraction thereof to 10.06m

d. Indication of danger

Supporting structures shall be provided with an indication of danger in a location where it is easily read. This shall not apply when insulated conductors are used for overhead transmission lines with a nominal voltage less than or equal to 33kV.

e. Definition of an Urban Area or Other Densely Built-up Area

An urban area or other densely built-up area shall be defined according to the building-to-land ratio specified in Table 3.6.4(d)

Table 3.6.4(d)

	An urban area or other densely built-up area
New transmission conductor (when installed)	The building-to-land ratio is no less than 25%.
Existing transmission conductor	The building-to-land ratio is no less than 30%.

3.6.5 Regulations for Side-by-side Installation and at Adjacency to and Crossing with Other Objects

3.6.5.1 Alternative provision

a. Where the condition of Clause 3.6.2 cannot be met, the line shall be erected so that the minimum horizontal distance in meters of the nearest conductor in still air is not less than-

   (Conductor sag at maximum design temperature PLUS length of suspension insulator string) PLUS B, where "B" is a constant dependent on the voltage between phases of the conductors of the line-

415Volts - 11,000 Volts	2.4 meters
33,000 Volts	3.0 meters
132,000 Volts	4.0 meters
330,000 Volts	6.0 meters
Over 330,000 Volts	9.0 meters

b. Where the conductors of the circuit are fully insulated the constant "B" may be reduced by 50%.
c. In the case of specially designed fully insulated serial cables clearance to buildings may be reduced at the discretion of NERC.
d. No building or other structure shall be erected under or adjacent to an electric line without adhering to the provisions of this standard.

3.7 Particulars of Installation for Side-by-side Use and at Adjacency to and Crossing with Other Objects

3.7.1 Side-by-side Use Installation with Other Objects

All crossings of power lines - road crossings, railway crossings, river crossings, power line to power line and power line to telecommunication lines and other objects - shall be done to satisfy requirements of this Regulation, applicable Codes, Standards, Specifications, the requirements of concerned authorities owning the en-route utility in respect of safety of its users and security of the Transmission System as per good industry practice. Necessary clearances, maximum permissible spans and requirements of mechanical and electrical parameters shall be observed in respect of all.

3.7.1.1 Installation with Distribution Conductors

a. When overhead transmission conductors with a nominal voltage higher than 33kV and overhead distribution conductors are installed on the same supporting structure, the installation shall be carried out in accordance with the requirements of Chapter 5.
The electrical conductor with a higher voltage shall be installed above the electrical conductor with a lower voltage, using separate cross arms.

i. Clearance
The clearance between any overhead transmission conductor and any overhead distribution conductor shall be not shorter than the values specified in Table 3.7.1.1(a)

ii. Strength of overhead distribution conductors
Overhead distribution conductors shall be any of those specified in the following items except for cases where cables are used:

a. Those with a tensile strength no less than 5 kN where the span of the overhead distribution conductor is not longer than 50m

b. Those with a tensile strength no less than 8 kN where the span of the overhead distribution conductor is longer than 50m.

c. Overhead transmission conductors with a nominal voltage over 33kV but below 132kV and low-voltage overhead distribution conductors shall not be installed on the same supporting structure.

When overhead transmission conductors with a nominal voltage over 33kV but below 132kV and medium-voltage overhead distribution conductors are installed on the same supporting structure, the installation shall be carried out in accordance with the following requirements:

i. Position of installing electrical conductors
Overhead transmission conductors shall be installed above overhead distribution conductors using separate cross arms. This shall not apply where such overhead

distribution conductor is installed together with overhead distribution conductor for the SWER system.

ii. Strength of overhead transmission conductors
The overhead transmission conductors shall be the stranded wires with a tensile strength no less than 30 kN excluding the case where they are cables.

iii. Transmission line strengthening work
Overhead transmission lines shall be installed according to the provisions for type 2 transmission line strengthening work in Table 3.7.1.1(a).

iv. Clearance

d. The clearance between any overhead transmission conductor and any overhead distribution conductor shall be no less than the values specified in Table 3.7.1.1(b).

Table 3.7.1.1(a)

Nominal Voltage	Clearance
Higher than 33kV	Value obtained by adding 6 cm for every 10 kV and fraction thereof over 33kV to 2.0 m (or 1 m when the overhead transmission conductor is a cable and the overhead distribution conductor is an insulated conductor or a cable)

Table 3.7.1.1(b)

System Voltage Between Phases	Clearance
Not exceeding 400Volts — insulated	0.2 m
Not exceeding 400Volts - un-insulated	0.6 m
Over 400Volts but not exceeding 33,000 Volts	1.8 m
Over 33,000 Volts but not exceeding 132,000 Volts	2.4 m
Over 132,000 Volts but not exceeding 330,000 Volts	4.0 m
Over 330,000 Volts but not exceeding 750,000 Volts	m

3.7.1.2 Strength of Overhead Transmission Conductor

Overhead transmission conductors shall be installed according to Clause 3.7.1.1(b) (iii)

a. Overhead transmission conductors with a nominal voltage higher than 132kV and overhead distribution conductors shall not be installed on the same supporting structure excluding the case of the following paragraph.

b. Where any overhead transmission conductor or any overhead distribution conductor to be connected with any low-voltage electric machine or appliance to be installed on the supporting structure of the overhead transmission line is installed on the same supporting structure, the installation shall be carried out according to the provisions of Clause 3.7.1.1(a). Also, the clearance between the overhead transmission conductor and the overhead distribution conductor shall be no less than the values specified in Table 3.7.1.1(b) to be transferred to distribution

3.7.1.3 Installation with Telecommunication Conductors

a. The provision of Clause 3.7.2.3b to 3.9.2.5d shall apply where the licensee intends to place an electric line, other than a service line, in the proximity of over or under Telecommunications line.

b. Other than in the case of a fully insulated services line, all electric lines, except with the written authority of the NCC, shall cross over communication lines with a minimum clearance, under the most adverse operating conditions at the point of crossing of :

Table 3.7.1.3

System Voltage Between Phases	Clearance
Not exceeding 400Volts – insulated	0.2 m
Not exceeding 400Volts - un-insulated	0.6 m
Over 400Volts but not exceeding 33,000 Volts	1.8 m
Over 33,000 Volts but not exceeding 132,000 Volts	2.4 m
Over 132,000 Volts but not exceeding 330,000 Volts	4.0 m
Over 330,000 Volts but not exceeding 750,000 Volts	7.0 m

i. So far as may be practicable the licensee shall leave one side of each street free for telecommunication line and where the street is continuous the licensee's line shall be kept to the same side of the street for the whole distance.

ii. Except with the permission of NCC or other relevant statutory body all overhead lines shall be placed on the opposite side of the street to that on which any telecommunication lines are erected, and where the erection or operation of the electric lines necessitates an alteration of an existing telecommunication line, and such alteration is approved by the NCC, the expense of the alteration shall be borne by the licensee; provided that where existing telecommunication lines of the Telecommunications Service Providers occupy both sides-of the street that Organization shall bear the cost of putting all telecommunication lines on the one side of the street or if agreeable to the licensee, consent to an arrangement for the joint use of poles on both sides of the street.

iii. Where electric lines are on one side of the street and telecommunication lines on the other, and service is required to be given from either side to the other, the licensee and the telecommunication Service Provider shall give to each other reasonable facilities as far as possible to effect supply. Where possible electric service lines, unless fully insulated, shall pass over telecommunication service lines otherwise pass under electric lines.

3.7.1.4 *Low-Voltage Appliances on Towers*

Where any low-voltage machine or appliance to be installed on the supporting structure of the overhead transmission lines is installed above overhead transmission conductors, it shall be installed in accordance with the following requirements. Notwithstanding, this shall not apply where the overhead transmission conductors are cables.

a. The electrical circuit to be connected to a low-voltage machine or appliance shall not be connected to any other loads.
b. Where the electrical circuit as specified in the preceding item is coupled with another electrical circuit through a transformer, an insulating transformer shall be used.
c. One terminal on the loaded side of the insulating transformer as specified in Clause 3.8.4(b) preceding item or a neutral point shall be provided with class A earthing work.
d. Metal cases of low-voltage machines and appliances shall be provided with class D earthing work.

3.7.2 Installations at Adjacency to and Crossing with Other Objects

3.7.2.1 *Adjacency to and Crossing with Buildings*

A line may be erected over or adjacent to a building provided that-

a. The radial distance in meters from the point of attachment of the suspension insulator (or conductor if attached to a fixed insulator) of the lowest conductor, to any part of the building is not less than:

   (Conductor sag at maximum design temperature + length of suspension insulator string) + A, where A is a constant dependent on the voltage between phases of the conductors of the line)

   400Volts to 11,000 Volts ……………………..….. 2.4 meters
   33,000 Volts …………………………………......3.0 meters
   132,000 Volts .... 4.0 meters
   330,000 Volts .... 6.0 meters
   Over 330,000 Volts .... 8.0 meters
b. Where the conductors of the circuit are fully insulated the constant "A" may be reduced by 50%.

3.7.2.2 *Adjacency to and Crossing with the Roads*

An overhead conductor may not cross a road at a more acute angle than 45°, unless special permission is obtained from NERC.

3.7.2.3 Adjacency to and Crossing with the Waterways

a. The height of an electric line under the most adverse conditions, above the highest recorded water level, over harbours, rivers and waterways, shall not be less than that required by the appropriate authorities for physical safety clearance plus a minimum electrical safety clearance of 3m or 1mr per 78 kV phase to neutral voltage of the electric line, whichever is greater.

b. The licensee shall at least within thirty days and not more than ninety days prior to the placing of such work serve written notice on the appropriate authorities specifying the intended use of the works, the voltage of operation and such other information that the authorities may require him to supply.
c. Every notice served in conformity with Clause 3.7.2.3b shall be accompanied by a plan of suitable scale indicating the site of the crossing, the location of all supports, stays, struts, switches, transformers and other apparatus intended to be used.
d. The authorities may within 21 days of the receipt of such a notice of intention served under Clause 3.7.2.3b serve a counter notice on the licensee
   i. Objecting to the siting of the works specifying the reason in the counter notice; and
   ii. Requiring protective features to be fitted, such features to be specified in the counter notice.

3.7.2.4 Adjacency to and Crossing with Railway Lines

The provision of Clause 3.7.2.3b to 3.9.2.5d shall apply where the licensee intends to place an electric line, other than a service line, in the proximity of, over or under a railway line.

a. An overhead conductor may not cross a railway track at a more acute angle than 60° unless special permission is obtained from the Nigerian Railway Corporation.
b. Minimum clearances shall be as follows:
   i. 132 kV circuits: over rail top 7.3 meters
   ii. 330 kV circuits: over rail top 8.4 meters;
   iii. Minimum height above rail level of the lowest wire or any portion of a guard or cradle guard under conditions of maximum sag: 6 meters
c. No supporting structure shall be situated nearer to the centre line of the track than the total height of the supporting structure plus 2.5 meters.
d. When the railway line is in a cutting, the supporting structure must be at a distance from the edge of the cutting not less than its total height.

3.7.2.5 Adjacency to and Crossing with the Airfields

The provision of Clause 3.7.2.3b shall apply where the licensee intends to place an electric line in the proximity of an airfield.

3.7.2.6 Adjacency to and Crossing with the Broadcasting Aerials

The provision of Clause 3.7.2.3b shall apply where the licensee intends to place an electric line, other than a service line, in the proximity of a radio or television aerial.

3.7.2.7 Approval in Specific Instances

Notwithstanding the foregoing, where the regulated clearances are so unattainable, NERC may, in specific instances, authorize the use of reduced clearances subject to such additional safety precautions in the form of warning notices, warning lights or crash bars, as it may deem necessary.

3.7.2.8 Adjacency to and Crossing with Distribution Conductors and Telecommunication Conductors*Where overhead transmission conductors are installed in proximity to overhead distribution conductors or overhead telecommunication conductors (hereinafter referred to as "overhead distribution conductors or the like"), they shall be installed in accordance with the following requirements:*

3.7.2.8.1 Proximity of Overhead Transmission Conductors with a Nominal Voltage over 33kV to Overhead Distribution Conductors

Where overhead transmission conductors with a nominal voltage over 33kV are installed in proximity to overhead distribution conductors or the like, they shall be installed in accordance with the following requirements:

a. **Clearance**

The clearance between overhead Transmission conductors and overhead distribution conductors or the like or their supporting structures (including guys and pole braces) shall shall be no less than the values specified in Table 3.7.2.8.1.

Table 3.7.2.8.1

Clearance (m) / Object		**Classification of Overhead Transmission Conductor**		
		Cable	**Insulated conductor**	**Others**
Overhead distribution conductor	Cable	0.5	0.5	1
	Insulated conductor	0.5	1	2
	Others	1	2	2
Overhead telecommunication conductor or supporting structure of overhead distribution conductor or the like		0.5	1	2

b. **Horizontal clearance**

The horizontal clearance between overhead Transmission conductors and overhead distribution conductors or the like shall be no less than 2m. This shall not apply under any of the following conditions:

i. Where the overhead distribution conductors or the like have a tensile strength no less than 10 kN or they are cables.

ii. Where the overhead telecommunication conductors are installed with messenger wires using galvanized steel wires with a diameter no less than 4 mm or with a tensile strength no less than 4 kN, or when the overhead telecommunication conductors are service wires with spans no longer than 15 m.

iii. Where the vertical clearance between the overhead Transmission conductors and the overhead distribution conductors or the like is at least 6m.

iv. Where the overhead Transmission conductors with a normal voltage lower than 132kV are insulated conductors or cables.

3.7.2.8.2 Crossing Over Overhead Distribution Conductors or the like

Where an overhead transmission conductor is installed crossing over an overhead distribution conductor or the like and when it is installed above an overhead distribution conductor, the overhead transmission line shall be installed in accordance with the following requirements:

***a.* Clearance**

The clearance between overhead transmission conductors and overhead distribution conductors or the like or their supporting structures shall comply with Clause 3.7.2.8.1.

***b.* Others**

The overhead distribution conductor or the like (the uppermost one when there are two or more located vertically) shall have a tensile strength no less than 10 kN or it is a cable.

This shall not apply where overhead transmission conductors are insulated conductors with a nominal voltage no higher than 33kV or cables with a nominal voltage below 132kV.

3.7.2.8.3 Adjacency to and Crossing under Overhead Distribution Conductors

(i) Adjacency under overhead distribution conductors

Overhead transmission conductors shall not be installed below overhead distribution conductors or the like within a horizontal distance equivalent to the height of their supporting structures above the ground surface.

(ii) Crossing under overhead distribution conductors or the like

Where overhead transmission conductors are installed across overhead distribution conductors or the like, the overhead transmission conductors shall not be lower than the overhead distribution conductors or the like.

3.7.2.8.4 Adjacency to and Crossing with Special Overhead Distribution Conductors

Where overhead transmission conductors are installed close to or across the low-voltage overhead distribution conductors connected to low-voltage machines or appliances specified in Clause 3.7.2.8.2, the overhead transmission conductors need not necessarily conform to the provisions of Clause 3.7.2.8.1 (excluding the provisions for clearance).

3.7.2.9 Adjacency to and Crossing with Transmission Conductors

The minimum distance between the nearest conductors of circuits erected on separate supports such that they run along parallel routes shall be not less than that required to enable the safe maintenance of either circuit to be carried out without de-energizing the circuit that is not being maintained, and the horizontal separation shall be greater than the height of the highest support.

3.7.2.10 Adjacency to and Crossing of Overhead Transmission conductors with other ones

Where overhead transmission conductors are installed close to or across other overhead transmission conductors, they shall be installed in accordance with the following requirements:

(1) Transmission line strengthening work

The overhead transmission lines to be installed above or on the side shall be installed in accordance with type 3 transmission line strengthening work.

(2) Clearance

The clearance shall be as specified below. The clearance shall be secured to provide for the occurrence of such case that the electrical conductor dips at the maximum design operating temperature or sways in the wind.

a. The clearance between an overhead transmission conductor and another overhead transmission conductor shall be no less than the values specified in Table 3.7.2.10(a) depending on the higher nominal voltage of the two transmission conductors.

Table 3.7.2.10(a)

Nominal voltage	Type of electrical conductor	Clearance
No higher than 33kV	One overhead transmission conductor uses a cable and the other uses an insulated conductor or cable	0.5 m
	Both overhead transmission conductors use insulated conductors	1 m
	Others	2 m

Over 33kV	Both overhead transmission conductors use cables	The value obtained by adding 6 cm for every 10 kV and fraction thereof over 33kV to 1 m
	Others	The value obtained by adding 6 cm for every 10 kV and fraction thereof over 33kV to 2 m

b. The clearance between an overhead transmission conductor and a supporting structure of another overhead transmission conductor shall be no less than the values specified in Table 3.7.2.10(b).

Table 3.7.2.10(b)

Nominal voltage	Clearance
No higher than 33kV	2 m (or 1 m when the electrical conductor is an insulated conductor and 0.5 m when it is a cable)
Over 33Kv	The value obtained by adding 6 cm for every 10 kV and fraction thereof over 33kV to 2 m (or 1 m when the electrical conductor is a cable)

3.7.2.11 Adjacency to and Crossing with Other Facilities

3.7.2.11.1. Primary Proximity

Where overhead transmission conductors are installed in primary proximity to facilities other than buildings, roads, pedestrian crossing bridges, overhead telecommunication lines, overhead distribution lines and other overhead transmission lines (hereafter in this clause, referred to as "other facilities"), they shall be installed in accordance with the following requirements:

Clearance

The clearance shall be as specified below. The clearance shall be secured to provide for the occurrence of such case that the electrical conductor dips at the maximum design operating temperature or sways in the wind.

The clearance between overhead transmission conductors with a nominal voltage no higher than 33kV and other facilities shall conform to Table 3.7.2.11.1.

Note that the clearance shall conform to Clause 3.7.2.1 where overhead transmission conductors are installed above the buildings strong enough under which people can walk around freely.

Table 3.7.2.11.1

Classification of other facilities		Clearance		
		The electrical conductor is an insulated conductor	The electrical conductor is a cable	The electrical conductor is a bare conductor
Upper structural member of building	Above	2 m or longer	1.2 m or longer	2 m or longer
	below or on the side	1 m or longer	0.5 m or longer	
Part of building other than upper		1 m or longer	0.5 m or longer	2 m or longer

structural members or facilities other than buildings			

The clearance between overhead transmission conductors with a nominal voltage over 33kV and other facilities shall be no less than the value obtained by adding 6 cm for every 10kV and fraction thereof over 33kV to 2m (or 1m when the overhead transmission conductors are cables and not installed above the upper structural members of building).

3.7.2.11.2. Secondary Proximity or Crossing

Where overhead transmission conductors are installed in secondary proximity to other facilities or they cross above other facilities, they shall be installed in accordance with the following requirements:

Clearance

The clearance between overhead transmission conductors and other facilities shall conform to Clause 3.7.1.3.

3.7.2.11.3. Adjacency Under Others

Where overhead transmission conductors are installed below and close to other facilities, the horizontal clearance between the two shall be no less than 3 m, and the clearance between them shall conform to Table 3.7.2.11.1.

Note that the clearance between overhead transmission conductors and other facilities need not necessarily exceed 3m when the overhead transmission conductors use insulated conductors and have a nominal voltage no higher than 33kV or when cables and have a nominal voltage below 132kV.

3.8 Protection from Lightning and Falling Trees

3.8.1 Protection from Lightning

The following measures shall be taken for overhead transmission lines to reduce flashover by lightning and protect facilities against damage caused by flashover.

a. Overhead ground wires shall be installed for the overhead transmission lines with a nominal voltage over 33kV. Note that the distribution lines of SWER systems installed on the top of a tower can be regarded as overhead ground wires.

b. Arcing horns shall be installed for insulator devices of overhead transmission lines with a nominal voltage over 33kV.

c. An armor rod shall be installed at the electrical conductor grasping part of suspension insulator devices.

d. Lightening Arresters shall be installed at the appropriate locations on both sides of the power transformer.

3.8.2 Protection from Falling Trees

Overhead transmission lines shall be installed in accordance with any of the following requirements to protect the facilities against damage caused by a falling tree.

a. Cut trees by the necessary length in an area where the facilities could be damaged by falling trees.

b. Secure the height of electrical conductors so as not to damage the facilities by falling trees.

3.8.3 Protection from Intrusion

For the purposes of preventing climbing of lattice structure by unauthorized persons, anti-climbing devices shall be attached to all supports and to all stay wires, where the stay wires are so arranged as to facilitate unauthorized climbing.

3.8.4 Protection from Mechanical Damage

Where lightning conductors, earthing leads, or other uninsulated conductors are run down poles they shall be protected by a wooden casing or other insulating material for a height of at least three (3) meters from the ground.

3.8.5 Numbering and Danger Notices

a. All supports shall be numbered with a combination of symbols and alphabets to identify the line.

b. In the reticulation of a township the supports shall be numbered in accordance with the grid of the master plan.

c. All supports carrying high voltage conductors shall have danger notices attached. These danger notices shall be of metal enamelled or painted white and/or conventional with lettering and/or conventional signs in scarlet as approved by NERC.

d. Where the lines are erected on the side of a road the notice shall be so fixed that it is plainly visible from the road.

3.9 Underground Transmission Lines

3.9.1 Dielectric Strength of Underground Transmission Lines

Cables used for underground transmission lines shall have the dielectric strength that withstands the power frequency voltage, the lightning impulse voltage and the switching surge voltage that may be imposed on the cables.

Underground transmission lines shall withstand the dielectric strength tests using the test methods specified in NIS IEC 60840 or NIS IEC 60502-2 "Electrical tests after installation" depending on the voltage.

3.9.2 Cables of Underground Transmission Lines

3.9.2.1 Properties of Underground Cables

Cables that are used for underground transmission lines shall have the following characteristics:

a. **Electrical Conductors**

Electrical conductors of cables shall have the electric resistance specified in NIS IEC 60228 and shall be stranded wires composed of solid wires, such as annealed copper wire, annealed aluminium wire, hard-drawn aluminium wire and semi hard-drawn aluminium wire that satisfy the mechanical characteristics specified in Table 3.9.2.1

b. **Insulators**

A cable shall have an insulator that is a butyl rubber compound, an ethylene propylene rubber compound or a polyethylene compound and have an electric shielding layer made of metal provided on the insulated conductor, or shall be a lead-covered cable, aluminium-covered cable or a cable with some other metal cover.

Note that a cable used in an underwater transmission line specified in Clause 3.9.1 of this Regulation (Underwater Transmission Lines) may not necessarily have the electric shielding layer made of metal.

Deviation from the above shall be subject to the written approval of NERC.

Table 3.9.2.1
Conductor Mechanical Characteristics

Type of solid wire	Diameter of solid wire	Tensile strength (N/mm2)	Elongation (%)

Annealed copper wire	No less than 0.10, no more than 0.28	No less than 196, below (462 - 10.8d)	No less than 15.0
	More than 0.28, no more than 0.29		No less than 20.0
	More than 0.29, no more than 0.45		No less than 20.0
	More than 0.45, no more than 0.70		No less than 20.0
	More than 0.70, no more than 1.6		No less than 25.0
	More than 1.6, no more than 7.0		No less than 30.0
	More than 7.0, no more than 16.0		No less than 35.0
Annealed aluminium wire	No less than 2.0, no more than 5.2	No less than 59, below 98	No less than 10.0
	More than 5.2, no more than 7.0		No less than 20.0
Hard-drawn aluminium wire	No less than 1.2, no more than 1.3	No less than 159	No less than 1.2
	More than 1.3, no more than 1.5	No less than 186	No less than 1.2
	More than 1.5, no more than 1.7	No less than 186	No less than 1.3
	More than 1.7, no more than 2.1	No less than 182	No less than 1.4
	More than 2.1, no more than 2.4	No less than 176	No less than 1.5
	More than 2.4, no more than 2.7	No less than 169	No less than 1.5
	More than 2.7, no more than 3.0	No less than 166	No less than 1.6
	More than 3.0, no more than 3.5	No less than 162	No less than 1.7
	More than 3.5, no more than 3.8	No less than 162	No less than 1.8
	More than 3.8, no more than 4.1	No less than 159	No less than 1.9
	More than 4.1, no more than 5.2	No less than 159	No less than 2.0
	More than 5.2, no more than 6.6	No less than 155	No less than 2.2
Semi hard-drawn aluminium wire	No less than 1.2, no more than 1.3	No less than 98, below 159	No less than 1.2
	More than 1.3, no more than 1.5	No less than 98, below 186	No less than 1.2
	More than 1.5, no more than 1.7	No less than 98, below 186	No less than 1.3
	More than 1.7, no more than 2.1	No less than 98, below 183	No less than 1.4
	More than 2.1, no more than 2.4	No less than 98, below 176	No less than 1.5
	More than 2.4, no more than 2.7	No less than 98, below 169	No less than 1.5
	More than 2.7, no more than 3.0	No less than 98, below 166	No less than 1.6
	More than 3.0, no more than 3.5	No less than 98, below 162	No less than 1.7
	More than 3.5, no more than 3.8	No less than 98, below 162	No less than 1.8
	More than 3.8, no more than 4.1	No less than 98, below 159	No less than 1.9
	More than 4.1, no more than 5.2	No less than 98, below 159	No less than 2.0
	More than 5.2, no more than 6.6	No less than 98, below 155	No less than 2.2

d: diameter of solid wire (mm)

3.9.2.2 *Jointing of Underground Cables*

Cables shall be jointed using a joint box that conforms to the following requirements:

a. The joint box shall not increase the electric resistance of cables.

b. The joint box shall have the dielectric strength equal to or higher than that of cables.

c. The joint box shall have a sufficient mechanical strength.

d. The joint box shall have a corrosion-free structure.

3.9.2.3 ***Earthing of Underground Cables and Joint Boxes***

Class D earthing work shall be provided on metallic members used for covering cables for underground transmission lines, metallic parts of joint boxes and metallic parts of protecting devices that house the cables (except for cable support hardware). This shall not apply to the parts where anticorrosion measures are taken.

3.9.2.4 ***Prevention of Over-voltage for Underground Cables***

If a cable of an underground transmission line could be damaged by over-voltage generated by a lightning impulse from an overhead transmission line or a high-frequency surge from a switching operation at a power plant or substation, the following counter measures shall be taken severally or jointly.

a. Protection of Cable Insulation

i. Combination of earthing of a steel tower for overhead transmission lines with earthing of the termination joint box structure and the metallic sheath of the cable.

ii. Installation of a Surge Arrester.

b. Protection of Anti-corrosion Layer in Cables

i. Installation of parallel earthing wires.

ii. Installation of a protecting device for the anti-corrosion.

3.9.2.5 ***Electric Lines Crossing Waterways***

a. The height of an electric line under the most adverse conditions, above the highest recorded water level, over harbours, rivers and waterways, shall not be less than that required by the appropriate authorities for physical safety clearance plus a minimum electrical safety clearance of 3m or 1m per 78 kV phase to neutral voltage of the electric line, whichever is the greater.

b. The licensee shall at least thirty days and not more than ninety days prior to the placing of such work serve written notice on the appropriate authorities specifying the intended use of the works, the voltage of operation and such other information that the authorities may require him to supply.

c. Every notice served in conformity with Section 3.9.2.5b shall be accompanied by a plan of suitable scale indicating the site of the crossing, the location of all supports, stays, struts, switches, transformers and other apparatus intended to be used.

d. The authorities may within 21 days of the receipt notify the licensee of its decision which may be:

(a) approved;

(b) approved subject to any condition;

(c) prohibited and served a counter notice on the licensee:

i. objecting to the siting of the works specifying the reason in the counter notice
ii. requiring protective features to be fitted, within a stipulated period e.g. three (3) months and such features to be specified in the counter notice.

3.9.2.6 Proximity to Railway Lines

The provision of Clause 3.7.2.3b shall also apply where the licensee intends to place an electric line, other than a service line, in the proximity of, over or under a rail-way line.

3.9.2.7 Cables

All cables whether for A.C. or D.C. and for all voltages, shall be insulated as required and manufactured in accordance with appropriate Nigerian Standards. Where steel armouring is employed, it shall be effectively earthed and bonded at all joint boxes so as to be electrically continuous.

3.9.2.8 Trenching and Protection from Damage

a. The cables shall be laid at a depth of not less than 1m below surface level and in cases where two or more power cables are laid in the same trench a minimum distance of 300 mm should be maintained between the cables.

b. To prevent the cables being damaged by stones the cables shall be laid in a bed of sifted soil or sand and to prevent mechanical damage the cables shall be protected by inter-locked tiles sufficiently wide to give a minimum of 50 mm on each side of the cable and laid approximately 150 mm above the cables.

c. The cable route shall be indicated at surface level with cable markers at suitable intervals, particularly at positions where the cable changes direction.

3.9.2.9 Cables Entering the Ground

Where cables enter or leave the ground they shall be protected from a point at least half a meter below the ground level to a height above ground as may be considered necessary.

3.9.2.10 Railway Crossings by Underground Cables

All proposals in respect of railway crossings shall be submitted to the Nigeria Railway Corporation in accordance with Clause 3.9.2.5. All cables shall be drawn into non-metallic pipes, such as earthenware, fibre, asbestos, which must be laid at a minimum depth of 1.3 m below rail level measured to the top of the highest pipe, and shall be surrounded by not less than 250 mm of concrete. The pipes shall extend at least 300 mm beyond the sleeper ends and be bushed to prevent chafing and ingress of stones.

3.9.2.11 Road crossings by underground cables

Where cables have to cross under roads, they must be drawn into non-metallic pipes such as fibre or Harden Rubber. These pipes must be laid at a minimum depth of 1m below surface of the road measured to the top of the highest pipe and cable tiles shall be laid as in Clause 3.9.2.8. The end of the pipes should be packed with a suitable bushing to avoid chafing and the ingress of stones.

3.9.2.12 Proximity to Water and Petrol Pipes

Cables shall not be laid at a distance of less than 1.0 m from pipes carrying water or petroleum products.

3.9.2.13 Street Boxes

a. The covers of street boxes shall be so secured that they cannot be opened except by means of a special appliance and the licensee, shall inspect such boxes from time to time, for the presence of gas and suitable action shall be taken to check the influx and accumulation of gas.

b. High voltage lines shall not pass through the same street box as other electric lines unless they are enclosed in a strong metal casing effectively earthed.

c. Street boxes containing high voltage lines shall not contain water, gas or other service pipes, or electric lines belonging to another licensee.

3.9.3 Underground Installation of Cables

3.9.4.1. Underground Installation of Cables

a. Classification of Underground Installation
A cable of an underground transmission line shall be installed in conduit systems, culvert systems or direct burial systems.
b. Installation Methods
i. Conduit systems and culvert systems
Conduit and culvert systems shall be installed in accordance with the following requirements:

(a) These systems shall be rigid and durable and shall not affect other adjacent buried objects.
(b) Where these systems are buried under roads, they shall withstand the pressure from vehicles or other heavy objects and shall not affect the strength of the road.
(c) Buried depth shall be as follows:
(i) The buried depth under a road shall be over 1.0m.
(ii) The buried depth under a sidewalk shall be over 1.0m.

ii. Direct Burial Systems
Direct burial systems shall be installed in accordance with the following requirements:

(a) To protect cables against shock, the direct burial systems shall be installed using any of the following methods:

(i) Lay or nest underground transmission conductors in durable troughs and other protectors.

(ii) Use cables with durable insulating covers, such as copper bars and steel pipes, for underground transmission conductors and install them by covering the top and the side of the underground transmission cable with durable plates or conduits.

(b) Buried depth shall be as follows:

(i) The buried depth shall be over 1.2m in a place where there is a possibility of receiving pressure from vehicles or other heavy objects.

(ii) The buried depth shall be over 0.6m in other places.

3.9.4.2. Indication of Buried Cables

Where underground transmission lines are installed using a direct burial system or conduit system, they shall be marked in accordance with the following requirements:

a. The name of the line, the responsible person and the voltage shall be indicated.

b. Such indications shall be given noticeably with intervals of about 10m. This shall not apply to restricted areas or places where the position of the electrical conductors can be recognized clearly.

3.9.4.3. Structure of Conduits, Culverts and Manholes

a. Structure of a Conduit

A conduit shall have the structure that conforms to the following requirements:

i. A conduit shall withstand the pressure of vehicles and other heavy objects.

ii. A conduit shall be structured so that it is difficult for water to enter it.

iii. A conduit shall have the inside diameter that allows cables to be drawn in and out smoothly and the inner surface shall be flat and smooth.

iv. The radius of curvature of a curve on the conduit and the length of conduit between manholes shall be such that the tensile strength and the lateral pressure applied on cables when they are drawn in are less than the allowable limit.

b. Structure of a Culvert

A culvert shall have the structure that conforms to the following requirements:

i. A culvert shall have the structure that can withstand the pressure of vehicles and other heavy objects.

ii. A culvert shall be structured so that water can hardly enter into it.

iii. A culvert shall have the form and dimensions that allow smooth installation and maintenance work of cables. The tolerable bending radius of cable shall be taken into consideration particularly at bends and branch points of the culvert.

iv. If necessary, a drain, a ventilator, lighting, scaffolding for going up and down, a ladder and other facilities shall be installed.

c. Structure of a Manhole

A manhole shall have the structure that conforms to the following requirements:

i. A manhole shall have the structure that can withstand the pressure of vehicles and other heavy objects.

ii. A lid of a manhole shall be such that people other than operators cannot open it easily.

iii. A manhole shall be structured so that it is difficult for water to enter it and water entering it can be removed.

iv. Where a manhole has the size of $1.0m^3$ or larger and there is a possibility that explosive or flammable gas may enter it, the manhole shall be equipped with a device to diffuse the gas.

v. A manhole shall be structured so that cables can be installed, maintained and kept functional.

vi. If necessary, facilities for going up and down shall be installed in the gateway.

vii. If there is a possibility that a manhole lid can be moved by a cable accident, a chain shall be installed on the lid.

3.9.4 Particulars of Prevention against Underground Electrical Inductive Interference

3.9.4.1. Protection of Underground Telecommunication Lines from Electrical Inductive Interference

Underground transmission lines with a voltage over 33kV shall be installed at a sufficient distance from underground telecommunications lines to avoid causing interference with communications through the underground telecommunication lines as a result of leakage current or induction.

3.9.5 Underground Installations at Adjacency to and Crossing with Other Objects

3.9.5.1 Adjacency to and Crossing with Underground Telecommunication Lines

a. Clearance

Where underground transmission conductors are installed close to or across underground telecommunication conductors, they shall be installed in accordance with the following requirements:

i. The clearance between the underground transmission conductors and the underground telecommunication conductors shall be no less than 0.60m.

ii. When the clearance mentioned above is less than 0.60m, any of the following counter measures shall be carried out.

(a) Durable fireproof barriers shall be provided between the underground transmission conductors and the underground telecommunication conductors.

(b) The underground transmission conductors shall be nested in durable pipes that are non-flammable or are self-extinguishing and fireproof, and the pipes shall be installed in such a manner so as not to contact the underground telecommunication conductors directly.

b. Alternative Measures

Paragraph 3.9.5.1.a. does not apply in any of the following cases:

i. Where underground telecommunication conductors are communications lines for power maintenance and are optical fibre cables covered with materials that are non-flammable or are self-extinguishing and fireproof or optical fibre cables nested in pipes that are non-flammable or are self-extinguishing and fireproof,

ii. Where underground telecommunication conductors are installed not to contact the communications lines for power maintenance directly,

iii. Where underground telecommunication conductors are optical fibre cables covered with materials that are non-flammable or are self-extinguishing and fireproof or optical fibre cables nested in pipes that are non-flammable or are self-extinguishing and fireproof, and the responsible person has given the consent to the installation,

iv. Where underground transmission conductors have a nominal voltage below 132 kV and are installed with the approval of the person responsible for underground telecommunication conductors, and the clearance between the two is 0.1m or more.

3.9.5.2 Adjacency to and Crossing with Underground Distribution Lines

Where underground transmission conductors are installed close to or across underground distribution conductors, the clearance between the two shall not be less than 0.3m.

This shall not apply in any of the following cases:

a. Where each underground electrical conductor is:

i. Covered with materials that are self-extinguishing and fireproof, or

ii. Nested in durable pipes that are self-extinguishing and fireproof.

b. Where either of those underground electrical conductors is covered with non-flammable materials

c. Where either of those underground electrical conductors is nested in durable pipes that are non-flammable

d. Where durable fire-resistant barriers are provided between those underground electrical conductors

e. Where those electrical conductors are installed close to or across each other in a manhole

3.9.5.3 *Adjacency to and Crossing with Other Underground Objects*

a. Adjacency to and Crossing with Gas Pipes and Oil Pipes
Where underground transmission conductors are installed close to or across pipes that contain flammable or toxic fluid and the clearance between the two is no more than 1.0m, the underground transmission conductors shall be housed in durable pipes that are non-flammable or are self-extinguishing and fireproof, and such pipes shall be installed not to contact the pipes containing flammable or toxic fluid, excluding the case where durable fire-resistant barriers are provided between the underground electrical conductors and the pipes.

b. Adjacency to and Crossing with Water Pipes
Where underground transmission conductors are installed close to or across water pipes, steam pipes or the like and the clearance between the two is not more than 0.30m, the underground transmission conductors shall be housed in durable pipes that are non-flammable or are self-extinguishing and fireproof, excluding the case where durable fire-resistant barriers are provided between the underground electrical conductors and the pipes. This shall not apply to such cases where the water pipes, steam pipes or the like are non-flammable or are covered with non-flammable materials.

c. Placing electric cable below ground with respect to telecommunication lines
Where telecommunication lines are placed below ground in any street and the licensee desires to place his works below ground in the same street they shall be placed on the opposite side of the street to the telecommunication line unless the Telecommunications Service Provider expressly authorizes in writing a relaxation of this requirement. Any such relaxation shall be subject to such conditions as to the provision of minimum separating distance and protective features which at its discretion he deems it desirable and necessary to impose for the protection of the telecommunication cable.

d. Exchange of plans
Where it appears that works of the licensee or telecommunication lines have been placed below ground, the licensee or the Telecommunications service provider may on Written application require the licensee or the Nigerian Communications Commission

(NCC), as the case may be, to furnish a plan of a suitable scale indicating the nature, course and depth of any existing works placed below ground. Any request made under the provision of this Clause, shall be complied with within thirty days of the original application. Plans shall be black or coloured lines on a white background having the true and magnetic north legibly marked.

e. Breaking up streets

i. A licensee shall not break up streets for the purpose of placing new works, including works in replacement of existing works, unless they shall have served notice of their intention on the responsible administrative authority, in addition to the local authority, for the repair of any street to be broken.

ii. Every notice required to be served under the provision of the Clause 3.9.5.3(e)(i)above shall be served at least thirty days but not more than ninety days prior to the date on which it is intended to break up any street or streets, and shall be accompanied by a plan of a suitable scale indicating the course, nature, width and depth of all intended excavations and the purpose thereof.

iii. The local authority or the road authority responsible for normal maintenance of the street or both may within 21 days of receipt of a notice served under the provisions of Clause 3.9.5.3(e)(i) serve a counter notice on the licensees requiring them to amend the scheme the reason thereof being stated in the counter notice.

iv. Where no counter notice is served on the licensee as provided for the works shall be deemed to be approved and it shall be lawful for the licensee to proceed with the works on the expiration of the term specified in the notice served under Clause 3.9.5.3 (e)(i) above.

v. Streets shall only be broken up in strict conformity with the original theme or any amendment thereof required by counter notice served under Clause 3.9.5.3(e)(iii).

vi. Where a licensee is of the opinion that the requirements of a counter notice served under Clause 3.9.5.3(e)(iii) are unreasonable and is unable to reach an amicable settlement with the local authority or the road authority or both, the matter shall be referred to the NERC.

f. Licensee liable for reinstatement of streets broken up

The road authority will reinstate any street broken up by the licensee and may charge the licensee the cost of so doing.

i. Location of cable, boxes to be agreed

Prior to placing in position in any street, the location of such cables or other works to be placed below ground, and of any street boxes or works to be placed above ground, shall be approved by the local authority or where the local authority does not maintain or repair the street, the road authority.

ii. Protection of a water authority

Where a piped water supply is provided in any area in which the licensee proposes to place any new works, the water authority not being a local authority, shall be deemed, for the purposes of this Part to be a local authority, and the provisions of clauses (e) and f(ii) above together with the following special conditions, shall apply–

(a) on receipt of the notices, required to be served under the provisions of Clause 3.9.2.3 (e), the Water Authority shall within twenty-one (21) days, furnish a plan of a suitable scale indicating the course, depth and any other relevant information relative to water mains likely to be affected by the proposal. Where no plan is furnished by the Water Authority within the said twenty-one days it shall be deemed that no mains exist

(b) on receipt of the plan referred to in Clause 3.9.5.3 (f) (ii) (a) above hereof the licensee shall take such steps as may be necessary to ensure that, in placing their works, the separating distance between the respective works is either not less than 1m or where this separating distance is impracticable such lesser distance as may be mutually agreed to in writing by the respective parties.

(c) in the event of any differences or dispute arising between the parties the matter shall be settled in the manner provided for in Clause 3.9.5.3 e(vi) above

g. Works affecting Telecommunications Service Providers

i. Where the licensee intends to place any new high voltage works within 150 meters of any telecommunication or telephone line operated by a Telecommunications Service Provider, the licensee shall at least thirty days and not more than ninety days prior to the placing of such works serve written notice on the Telecommunications service provider specifying the intended use of the works, the maximum power it is intended to handle, its voltage of operation and such other information the Telecommunications service provider may require the licensee to furnish.

ii. Every notice served in conformity with Clause 3.9.5.3.(e)(i) and 3.9.5.3 (g)(i) above shall be accompanied by a plan of a suitable scale indicating the course, nature and depth of all intended excavations, switches, transformers, and other apparatus intended to be used.

iii. The Telecommunications Service Provider may within 21 days of the receipt of a notice of intention served under Clause 3.9.5.3(g)(i) above hereof serve a counter notice on the licensee requiring them to-

(a) re-route their works;
(b) provide protective features to be specified in the counter notice between his works and the intended works;
(c) provide guarding between his works and those of the licensee which guarding he may provide at the expense of the licensee if he so advises the licensee in the counter notice.

h. Lines of other licensees

The provisions of Clause 3.9.5.3(g)(i) shall apply where the licensee intends to erect works in the proximity of other licensee's lines or works and for the purpose of this Clause the Telecommunications Service Provider shall be deemed to mean other licensees whose lines or works is affected by the action of the licensee.

i. Lines crossing or erected on railway or navigable waterway

Where it is intended to erect any works along or across whether under or over any railway lines or a navigable waterway, notices similar to the provisions of Clause 3.9.5.3(g)(i) shall apply for the purpose of this Clause.

j. Commissioning of new projects

1) A licensee shall not bring new projects into use until the projects have been inspected and certified fit and if necessary, tested by an Inspecting Engineer to determine compliance with this Regulation, in particular the earth test results shall comply with the provisions of Nigerian National Code of Practice on Earthing.

2) At least fourteen days prior to the date on which it is desired to bring into use any aforesaid projects, the licensee shall serve notice on the NEMSA sending a copy to the NERC, specifying the date on which the projects or any part thereof will be completed and ready for inspection. Every such notice shall be accompanied by-

a. a plan and description of the projects as erected with complete set of as-built drawings;
b. Copies of any notices and plans served under the provisions of clauses 3.9.5.3.f(ii), and f(ii) a, b, c.
c. Copies of any counter notices received.

3) On receipt of a notice under the provisions of Clause 3.9.5.3 j(ii) above NEMSA shall inspect the relevant projects and if he is satisfied that there is compliance with the Regulations then certify, in writing, sending the original certificate to the licensee and a copy to the NERC, provided that any certificate issued under the provisions of this Regulation shall not be deemed to relieve the licensee of any of their obligations under the provisions of the Electricity Act 2023 or of these Regulations.

4) Under no circumstance shall any electric power project that requires commissioning test(s) be commissioned without regards to 3.9.5.3 j(i) to j(ii).

3.10 Special Transmission Lines

3.10.1 Underwater Transmission Lines

Underwater transmission lines shall be installed in a place where they will not be damaged so that they will not be exposed to risk, and shall conform to the following requirements:

a. Cables shall be used for the electrical conductors.

b. Cables shall be housed in durable pipes or cables armoured with metal wires with a mechanical strength not less than that of galvanized steel wires with a diameter of 6mm shall be used for underwater transmission lines.

3.10.2 Transmission Lines Over Bridges and Others

a. Transmission lines installed on the side or on the lower surface of bridges shall be installed in accordance with the following requirements:

i. Cables shall be used for the electrical conductors.
ii. Cables shall be housed in durable pipes or troughs, or shall be installed so that nobody can touch the cables.
iii. Class A earthing work shall be provided to the metallic parts of tubes and other protectors that contain cables, metallic electrical conductor joint boxes, and metallic members to be used for covering the cables (Class D earthing work be provided where they are installed so that nobody shall touch them), except where corrosion prevention measures are provided or the electric resistance to the ground is not more than 10Ω.
iv. Where electrical lines over bridges are installed close to or across other facilities, the clearance between them shall be not less than the values specified in Table 3.10.2(a)

Table 3.10.2(a)

Other facilities	Clearance
High, medium or low voltage circum-structural conductors, telecommunication conductors, water pipes and gas pipes	15cm
Other facilities (excluding overhead and rooftop electrical conductors)	30cm

b. Particularities of Earthing of Various Classes

i. Earthing arrangements and protective conductors
The earthing electrode, earthing conductor and protecting earthing conductor shall conform to NIS/NIS IEC 60364-5-54 (1980-01) and the Nigerian National Code of Practice on Earthing. The minimum diameter of protective earthing conductors shall conform to Part 4, Section 1.3.14 of the Distribution Code, Version 01 as amended.

ii. Classification of Earthing Work
Earthing work shall be classified into Class A, Class B, Class C and Class D, and each resistance value to earth is listed in Table 3.10.2(b).

Table 3.10.2(b)
Classification of earthing work

Classification of earthing work	Resistance to earth	Conditions for Easement of Resistance Value
Class A	10Ω or less	

Class B	$\frac{230}{I^{*}I}$ Ω or less	In cases where voltage to earth of a low-voltage electrical circuit exceeds 330kV due to power contact between the medium-voltage electrical circuit and the low-voltage electrical circuit of the transformer, when an earth leakage breaker that cuts off the electrical circuit within 1 second is installed, $\frac{600}{I^{*I}}$ Ω or less. However, if a calculated value becomes less than 5Ω, it shall not be necessary to obtain resistance less than 5Ω, and if a calculated value becomes more than 10Ω, it shall not be necessary to obtain resistance more than 10Ω.
Class C	10Ω or less	In the case where earthing arises in a low-voltage electrical circuit, when an earth leakage breaker that acts within 0.5 seconds is installed, the resistance value shall be 500Ω or less.
Class D	100Ω or less	In the case where earthing arises in a low-voltage electrical circuit, when an earth leakage breaker that acts within 0.5 seconds is installed, the resistance value shall be 500Ω or less.

Note: **I means Single-line earth fault current (I) of an electrical circuit in the medium-voltage side in Class B earthing which may conform to an actual value or either of the following values.*

3.11 Grid Modernization and Transformation

3.11.1 General

The Grid modernization and transformation shall be driven by the global requirements for decarbonization, decentralization and digitalization through the integration of renewable energy, energy efficiency system, virtual power plant, distributed generation, digital substation, micro grid, grid digitalization, Smart Grid, Battery Energy Storage System (BESS) and increasing customer control over their energy usage.

3.11.2 Requirements for the Renewable Energy Integration into Transmission Network

Transmission System requirements for renewable energy integration: The Nigerian Independent System Operator (NISO) shall evaluate the end to end processes required for the integration of renewable energy sources into the power grid as follows:

i. **Information Technology and Data Architecture:** Modular architecture with integrated data product enabling corporation with energy market platforms and all areas of the business.
ii. **Modelling, Simulation and Sensitivity Analysis:** Scenario - based stochastic models for techno - economic optimization of energy system.
iii. **Prior to Grid Applications:** Optimization of capacity estimation methodology coordinated with planning model; increase visibility of grid constraints and minimal application requirements for renewable energy power developers
iv. **Grid Application Process:** Revision of connection requirement to streamline the process in line with the provisions of Section 11.3 of the Grid Code. Definition of technically standardized connection models and ancillary equipment offered to renewable energy power developers shall be in accordance with IEC 62934, IEC 61850, IEC 61970, IEC 63102, and IEC 63411,

v. **Construction and Energization:** Efficient Capex delivery (Manage supply chain and inflation risk) and equipment standardization

vi. **Technology:** New hardware optimizing usage of existing grid capacity supported by grid management, monitoring and storage solutions in accordance with IEC 62325, (301,351, and 451)

vii. **Flexibility Services:** Increase facilitation of different resources (e.g. Customer renewables) across flexibility services, congestions services, reserves, frequency response and inertia capacity

3.11.3 Virtual Power Plant (VPP)

VPP aggregates dispersed Distributed Energy Resources (DERs)/ Consumer Energy Resource (CERs) to support the Grid. VPP behaves similar to traditional power plants, with standard attributes, including minimum and maximum capacity, and ramp up and ramp down capabilities. All VPP shall be fitted with a central IT control system for processing data like weather forecast, electricity pricing and power trends to optimize dispatchable (DERs) operations in compliance with IEC 63189 (1 and 3, 2023) IEC 61850, IEC 62934, and IEC 62477 – 1

3.11.4 Energy Efficiency

Energy Efficiency standards aims to reduce Energy consumptions by setting performance requirements for products and buildings. These standards are applicable to areas like lighting power density, and performance of heating and cooling system in compliance with IEC 60364 – 8 – 1, IEC 60034, IEC13273 – 1 and IEC 61800 – 9

3.11.5 Distributed Generations (DG)

DGs: Refers to electricity production from smaller, decentralized energy sources, located near the point of consumption. DGs are generally produced from Distributed Energy Resources (DERs) which include technologies like solar panels, wind turbines and fuel cells. All DGs shall promote energy independence, reduce transmission losses, enhance grid resilience and complies with IEC 62786 – 1 2023, IEC 61850 – 7-420, IEC 61400 -25 (wind power), IEC 61727, and IEC 62479

3.11.6 Digital Substations

Digital substations shall encompass all aspect of the state of the art protection, control, and monitoring equipment or tools to improve flexibility, safety, security, and customer satisfaction in compliance with IEC 61850, IEC 61869, and IEC 62271

3.11.7 Micro Grid

A Micro Grid is a decentralized group of power sources and loads that normally operate as a connected and synchronous system within a synchronous grid but are capable of disconnecting and functioning autonomously as physical, technical, or economic conditions may require. A micro grid source can be fossil fuel or electricity with a combination of renewables and battery energy storage system. They supply electricity from renewables, and battery energy storage system. All micro grid shall comply with the provisions of IEC 62898, IEC 61850, IEC 62786, and IEC 63402

3.11.8 Grid Digitalization

Grid Digitalization leverages on digital technologies to facilitate more sustainable, reliable, efficient and affordable power system in compliance with IEC 61850, and IEC 62053 – 22

3.11.9 Battery Energy Storage Systems (BESS)

3.11.9.1 General

This standard is aimed at presenting technical specifications to be used in the development of Battery Energy Storage Systems (BESS) for grid stability. Relevant standards on the, Ttechnical specification, Safety considerations for grid integration, Operation and maintenance have been included in this standard.

3.11.9.2 Scope

This regulation shall apply to distributed generation and grid-connected BESS at the 11kV, 33kV, 132kV and 330kV networks. The minimum capacity of grid connected BESS shall be as specified in Table 3.11.8.2

Table 3.11.8.2

Minimum Capacity of Grid Connected BESS

S/N	Voltage Level (kV)	Minimum BESS Capacity (MW)
1	11	5
2	33	Below 20
3	132	20
4	330	50

3.11.9.3 BESS Technical Specifications

The technical specification of the BESS shall be in accordance of the provisions of IEC TS 62933-3-1, IEC TS 62933-3-2, IEC TS 62933-3-3 standards.

3.11.9.3.1 Battery System

The following shall be specified for the battery system:

a. Battery type (Li-ion, Lead-acid, Flow, etc.)
b. Capacity and energy rating in kWh or MWh
c. Voltage and current ratings
d. Cycle life and degradation rate
e. Thermal management system

3.11.9.3.2 Power Conversion System (PCS)

The following shall be specified for the power conversion system (PCS) in line with IEC TS 62933-3-2, and NIS IEC 62116 standards.

a. Inverter/Converter specifications
b. Efficiency and power factor requirements
c. Voltage and frequency operating range
d. Harmonics and THD limits

3.11.10 Grid Connectivity Standards

3.11.10.1 Interconnection Requirements

The following shall be required for the interconnection of BESS into the Grid in accordance with the provisions of appendix 3 of the Grid Code:

a. Voltage and frequency ride-through capabilities
b. Anti-islanding protection
c. Synchronization and reconnection procedures
d. Phase angle

3.11.10.2 Power Quality and Stability

The following indicators are required for the assessment of power quality in accordance with the provisions of section 10.1 and 10.2 of the Grid Code:

a. Voltage regulation and reactive power support
b. Flicker and harmonic distortion limits
c. Response time for grid services

3.11.11 Control and Monitoring System

The control and monitoring systems required for the BESS shall comprise of Battery Management Unit and Energy Management Unit with remote monitoring and control capabilities in line with the provisions of section 12.2, 20.15, 20.16 and 20.19 of the Grid Code. The communication protocols of the control and monitoring system shall be in accordance with the provisions of IEC 61850 standards.

3.11.12 Protection and Safety Systems

3.11.12.1 BESS Protection Systems

The protection requirements for the BESS shall be in accordance with the provisions of IEEE 1547 standards. In addition, the following protection schemes as provided in section 8 of this regulation are required at the connection interface:

a. Overcurrent/overvoltage/undervoltage protection
b. Short-circuit protection
c. Fire suppression and thermal runaway prevention
d. Grounding and isolation requirements

3.11.12.2 BESS Safety Systems

The safety requirements for the BESS shall be in accordance with the provisions of IEC 62933-5-1 standards and the Nigerian Electricity Health and Safety Code.

3.11.13 Communication and SCADA Integration

The BESS SCADA system shall meet the provisions of section 12.2 of the Grid Code for interface requirements, data reporting (real-time monitoring, alarms, logs) and Cybersecurity measures in line with IEC 62351 standards.

3.11.14 Installation and Commissioning

The installation and commissioning of BESS shall include the following in line with the provisions of IEC TS 62786-3, IEC 62786-1, IEC 62786-2, IEC 62786-3 requirements:

a. Site preparation and environmental conditions
b. Mechanical and electrical installation Procedures
c. Testing procedures (pre-commissioning and performance validation)
d. Compliance certification and documentation

3.11.15 Operation and Maintenance (O&M)

The operation and maintenance of BESS shall include the following in line with the provisions of IEC TS 62786-3, IEEE 2030.2.1-2019 requirements:

a. Routine inspection and maintenance schedule

b. Performance degradation monitoring
c. Fault detection and troubleshooting
d. End-of-life and recycling/disposal considerations

Chapter 4: Injection Substation Installations

4.1 Civil Works

4.1.1 Civil Design

The Design of civil works for Injection Substations shall be based on the following specifications: All materials used shall be in accordance with approved engineering designs and specifications in conformity with relevant extant Nigerian Industrial Standards and Codes.

Geotechnical Investigations shall be carried out on all proposed Injection Substation sites. The report of the soil tests shall form the basis for all related civil design works for Injection Substation construction.

a. **Foundations**: The Design and construction of Injection Substation foundations shall be in accordance with **BS 8004** Specifications based on the results of Geotechnical investigations for the site.
b. **Concrete Structures**: concrete structural works shall be in accordance with **BS 8110**.
c. **Structural Steel Works**: The design, fabrication and erection of structural steelworks shall be in accordance with **BS 5950**.
d. **Water Retaining Structures (Embankment)**: The design and construction of water retaining Structures/embankments shall be in accordance with **BS 8007**.
e. **Block Work/Brickwork:** The design and Construction of block work/brickwork shall be in accordance with the requirements of **BS 5628**.
f. **Sound Insulation:** All roof and wall cladding systems including ventilators, openings, windows, doors, etc., shall be designed and constructed such that the noise level emissions (dB) at the site boundary do not exceed the limits set by the Nigerian Electricity Health and Safety Code.

4.1.2 Site Preparation

The design, site preparation and execution of all related civil works as it affects the construction of Injection Substations shall be in accordance with the following guidelines:

4.1.2.1 Earthworks

Earthworks shall include, but is not limited to, the clearing of the site, the supply and compaction of fill materials, excavation and compaction of backfill materials for foundation, access road construction, drainage, trenches and final gravelling as specified in the Nigeria National Building Code (NNBC).

4.1.2.2 Access Road

Access road to Injection Substation sites shall not be less than 7.3 m wide from any adjoining/existing public road with adequate clearance for manoeuvring of heavy-duty vehicles.

Within substation fencing, roads to be provided for access along with car parking lot shall have capacity to accommodate a minimum of five cars with adequate clearance from installed equipment and building. Layout of the roads shall be based on layout drawing for the substation. Parking areas shall be provided for site personnel and visitors as per layout drawing. Adequate turning space for vehicles shall be provided and bend radius shall be set accordingly.

All access roads, up to the control room building, shall be constructed to have a minimum load-bearing capacity that will support the transportation of heavy-duty equipment up to 100MT. All access roads shall be provided with paving stones and clearly demarcated with side kerbs. The roadside kerbs used for the construction of all access roads shall be of a minimum thickness of 80 mm with compressive strength of not less than 450 kg/cm^2.

4.1.2.3 Property Fencing

All Injection Substations shall be fenced to prevent unauthorized access. The fence shall be constructed using either galvanized steel chain link or vibrated block work.

All perimeter fencing shall be designed to meet critical loading conditions peculiar to the site under consideration such as to withstand the prevailing wind speed within the environment.

4.1.2.4 Galvanized Steel Chain Link

Where the perimeter fence and the entrance gates are made of galvanized steel chain-link fencing and galvanized steel pipes as may be specified in the General Specification for materials and workmanship, they shall comply with the provisions of this Regulation. The height of the fence and the gates shall not be less than 2.50 m vertical with a further 0.5 m extended outwards from the site at 45^0 on to which 3 numbered rows of barbed wire shall be fixed. The midsections of the fence shall be kept taut by the introduction of steel stiffeners.

Fence posts shall be of galvanized tubular steel of diameter 50mm for intermediate posts and 75mm for angle and tensioned posts, 3.0m apart, on the average centre The fence posts shall have concrete foundation projecting 100mm above the finished laterite level but flushing with the top level of the crush rock. The top of the concrete foundation of the steel pipes shall be cambered to prevent water stagnations that might lead to rusting.

The vehicular and pedestrian gates shall be plastic coated chain link with galvanized steel frames/posts.

The widths of the vehicular and pedestrian gates in fully opened position shall be 5.0 m and 1.0 m respectively.

4.1.2.5 *Vibrated Block Wall*

Where the perimeter fence and the entrance gates are made of vibrated blocks, 228.6mm vibrated blocks shall be used. The height of the fence and the gates shall not be less than 1.90m vertical with a capping and fence wire finishing. The midsections of the fence shall be maintained with concrete reinforcement 3.0m apart on the average centres.

The vehicular and pedestrian gates shall be of plastic coated, galvanized or enamelled-steel sheet with galvanized steel frames/posts.
The widths of the vehicular and pedestrian gates in fully opened position shall not be less than 5.0m and 1.0m respectively.

4.1.2.6 *Areas Requiring Fencing*

Fencing shall be provided for the following areas:

a. Complete outdoor substation including Power transformer area.
b. Gates shall be provided for men and machines/equipment to be taken into and out of the substation.
c. Capacitor bank cage, which shall be part of the capacitor bank installed. Wherever necessary, anti-reptile fixture/arrangement shall be provided along with fencing.
d. Fencing of auxiliary Substation Transformer.

4.1.2.7 *Electric Fencing*

Where Electric Fencing is installed as part of security measures to prevent unauthorized entry and access into substation premises, it shall be mandatory that clearly marked Warning Signs be displayed within visible range of not more than six metres apart on all sides of the perimeter fencing in accordance with NIS IEC 60335-2-76.

4.1.2.8 *Electric Fencing Energizer*

Where Electric Fencing is installed as part of security measures, to prevent unauthorized entry and access, the pulse voltage released by the power energizer shall not in any way cause life threatening injury to unauthorized persons trying to gain entry or access into substation premises and shall be in accordance with NIS IEC60335-2-76.

4.1.3 Control Room Building

4.1.3.1 *Design*

The control room building design shall take the following into consideration:

a. The suitability of the structure to withstand possible major hazard events as defined in Nigerian Electricity Health & Safety Code, as amended.
b. The layout and the arrangement of switchgears, tripping units, etc are such as to ensure effective ergonomic operation of the indoor and outdoors equipment for normal operations and emergency situations including the provision of emergency

exits. Provision of emergency exits in control rooms shall be in accordance with the Nigerian Electricity

4.1.3.2 *Construction*

The construction of control room building shall conform with the requirements of the Nigeria National Building Code. The structural design and details of the control room building shall be able to guarantee the following stability conditions:

i. All possible combination of dead and service loads
ii. Wind loads
iii. Natural hazards due to seismic activities and flooding
iv. Fire and thermal loading

4.1.3.3 *Control Room Minimum Floor Area*

The minimum floor area for the control room building shall not be less than $200m^2$, which may be increased at the time of detailed engineering design to meet project requirements.

4.1.3.4 *Minimum Work Space*

An open workspace of a minimum of 1.2m shall be provided between the wall and the switchgears to allow for movement and access as well as maintenance.

4.1.3.5 *Other Criteria*

The building design shall also meet the following requirements:

i. Provide for easy access and maintenance of the equipment with, wherever required, fire resisting and or retarding materials for walls, ceilings and doors.
ii. Adopt use of materials that shall prevent dust accumulation.
iii. Individual structural members of the building frames shall be designed for the worst combination of forces such as bending moments, axial force, shear force and torsion.
iv. Permissible building loading stress shall be in accordance with the Nigeria National Building Code.
v. The Control Room building lighting shall be designed in accordance with the requirements of NIS IEC 60364.
vi. The Control Room building auxiliary services such as Heating, Ventilation and Air Conditioning Systems, fire prevention, detection and control systems and all other miscellaneous services shall be designed in accordance with the requirements specified in the Nigeria National Building Code.

4.1.4 Equipment Plinth

The construction of the equipment plinths shall take into consideration the site geotechnical investigation report and shall be designed to meet the load bearing capacity that will adequately support the weight of the intended equipment to be installed in the substation.

In addition, the design and construction of the equipment plinth shall accommodate the equipment manufacturer's specifications.

The power transformer plinth shall be of a minimum horizontal distance of 11.2 m from the control room building.

4.1.4.1 Plinth Filling

Plinth Filling shall be carried out with approved materials in layers not exceeding 150 mm watered and compacted with mechanical compaction machine or hard-tempers where mechanical compaction is not possible. The compacted surface shall be properly shaped, trimmed and consolidated.

4.1.4.2 Oil Sump

The oil sump provided shall be of a minimum depth of 1 m and width of 0.6m.

4.1.5 Drainage

The entire substation area shall be provided with adequate drainage facilities to prevent flooding and accumulation of water.

Building drains shall be provided for the collection and evacuation of storm water from the roof and adjoining facilities. The design of drain collectors shall be adequate to effectively evacuate storm water from the substation.

4.1.6 Cable Trenches

4.1.6.1 Design Factors

Cable trenches shall be constructed for use in Injection Substations. The separation between cables and their depths shall depend on the following factors:

i. Operating Voltages
ii. Ambient temperature
iii. Cable design temperature
iv. Soil Resistivity
v. Heat sources in the vicinity of cables
vi. Cable type
vii. Method of earthing
viii. Load cycle

4.1.6.2 Depth

Cable trenches shall be of a minimum depth of 1.0m except under the switchgear where the trench shall be of a depth of 1.2m and a minimum width of 800mm for cable trench and switchgear panels.

4.1.6.3 Provision of Manhole

Manhole capable of permitting bending radius of 3.0m shall be provided along the trench route prior to cable entry into the control room.

4.1.6.4 Cable Trench Not Drainage

Trenches must be watertight and must not be connected to the outside drainage system.

4.1.6.5 Size and Strength of Cover Slabs

Trench covers must be suitably constructed to support pedestrian traffic. The covers must be divided into sections of maximum of 1.0m lengths, each weighing not more than 20kg.

4.1.6.6 Levelling of Trench Cover Slabs

The trench cover when laid across the trench shall flush with the surrounding ground/floor level.

4.1.7 Security Post(s)

The Security Post shall be constructed in accordance with the requirements specified in Clause 4.1.1.

4.1.8 Graveling

The Injection Substation active switchyard area shall be demarcated using roadside kerbs and gravelled with 25mm aggregate chippings to a minimum depth of 150mm.

4.1.9 Landscaping

4.1.9.1 Location

Landscaping shall be carried out in non-active areas of Injection Substation.

4.1.9.2 Nature of Lanscaping in Non-active Areas

Non-active areas within the Injection Substation shall be landscaped for proper levelling, paving, sloping, consolidation and grassing.

4.2 Electromechanical Works

Electromechanical works to be carried out at Injection Substation shall include, but not limited to, the following:

4.2.1 Substation Design

Substation design shall be carried out in accordance with loading design parameters, calculations, site survey, engineering design layout, earthing and bonding requirements, and equipment specification for indoor and or outdoor types.

4.2.2 Equipment Layout

4.2.2.1 Design

a) Equipment layout design for Injection Substations shall take into considerations the type of usage i.e. indoor/outdoor and shall have enough spacing for operators to install, operate and move their equipment safely.
b) Equipment shall be located such that any other equipment may be removed within the layout with the remaining equipment in service and under load. A passageway of at least 2500mm wide shall be allowed for transformers and 1500mm wide for the high and low voltage boards.

4.2.2.2 Indoor Switchgears

Indoor switchgears shall be housed in well laid out buildings.

Materials, equipment and methods used in the manufacture of indoor switchgears shall conform to the requirements of the following standards:

a. Switchgear and control gear – NIS IEC 60694, NIS IEC 60298, NIS IEC 62271-200, NIS IEC 60529.
b. Circuit Breaker; NIS IEC 62271 – 100
c. Isolating and earthing switches – NIS IEC 62271-102
d. Current Transformer – NIS IEC 60185
e. Voltage Transformer – NIS IEC 60186
f. Relays – NIS IEC 60255

The LV and HV switchgear should be located near the door.

A clear passageway of at least 1.0m wide shall be allowed from each item of switchgear to the access door.

4.2.3 Busbar/Bay Arrangements

The Injection Substation busbar/bay arrangement shall be of single or double bus-bar arrangement constructed with galvanized steel channels or pre-stressed reinforced concrete poles of adequate sizes that shall give adequate ground to line clearance of not less than 4.2m.

4.2.4 Primary Equipment

Active switchyard area in the Injection Substation shall have the following primary equipment installed:

4.2.4.1. Transformers

Transformers to be installed in Injection Substations shall consist of the following:

4.2.4.1.1 Power Transformers for Distribution System

Power transformers shall conform to the requirements of NIS IEC 60076 series of standards with respect to all engineering designs, workmanship and latest revision of relevant standards.

Power transformers to be installed in injection substations shall meet the following minimum requirements.

a. The design, engineering, manufacture, installation, commission, and performance requirements of the applicable standards.
b. The range of capacity shall include 2.5MVA and up to 30 MVA, 33/11kV nominal voltage.
c. The power transformer shall be double copper-wound, three-phase, dry type or oil-immersed with ONAN/ONAF cooling system or both, and fitted with on-load tap changers for 7.5MVA transformers and above.
d. The system operating conditions shall conform with the provisions of the Grid Code, Distribution Code and NIS IEC 60076 (All Parts).
e. The power transformer and any supporting structures shall be adequately packaged and sealed against water ingress.
f. The power transformer shall conform with the standards of Engineering design , workmanship, maintainability and the extant standards relevant to the areas listed below in Table 4.2.4.1.1:

Table 4.2.4.1.1

S/No.	***Subject***	***Standard***
i.	Power transformers – Part 1: General	NIS IEC 60076 – 1
ii.	Power transformers – Part 2: Temperature rise for liquid-immersed transformers	NIS IEC 60076 – 2
iii.	Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air	NIS IEC 60076 – 3
iv.	Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors	NIS IEC 60076 – 4
v.	Power transformers – Part 5: Ability to withstand short circuit	NIS IEC ~~6~~ 60076 – 5
vi.	Power transformers – Part 6: Reactors	NIS IEC 60076 – 6
vii.	Power transformers – Part 7: Loading guide for oil-immersed power transformers	NIS IEC 60076 – 7
viii.	Power transformers – Part 8: Application guide	NIS IEC 60076 – 8
ix.	Power transformers – Part 10-1: Determination of sound levels – Application guide	NIS IEC 60076 – 10
x.	Power transformers –	NIS IEC 60076 – 13

	Part 13: Self-protected liquid-filled transformers	
xi.	Power transformers – Part 14: Design and application of liquid-immersed power transformers using high-temperature insulation materials	NIS IEC 60076 – 14

g. The power transformer shall be capable of supplying its rated power continuously under ambient temperature conditions without the temperature rise of the top oil exceeding 50˚C. The ambient temperature conditions are as follows:

i. Maximum ambient temperature of 50°C

ii. Maximum daily average ambient temperature of 35˚C

h. The power transformer may be overloaded during emergency up to 150% of its continuous rating in accordance with NIS IEC 60076-1

i. The power transformer tap changer (on-load) shall be suitable to compensate for system voltage variation of ±5% maintained at nominal tap position 33/11kV voltage ratio.

j. Vector group of the 11/0.415kV distribution transformers shall be Dyn11 and Dyn1 for 33/11 kV, 2.5MVA capacity and above in accordance with NIS IEC 60076 – 1.

k. The power transformer shall be of such capacity that it has taken into consideration the suppression of harmonic voltages especially the 3rd, 5th and 7th harmonics.

l. The power transformer shall be equipped with bushing current transformers suitable for protection and metering purposes.

4.2.4.1.2 Voltage Transformers (VTs)

Voltage transformers for Injection Substations shall be of indoor/outdoor type, wound type and shall conform with the requirements of NIS IEC 61869-3.

The secondary voltage shall be 110 Volts (phase to phase) at an operating frequency of 50Hz±2.5%.

The voltage transformers shall be suitable for base mounting on steel channel structure.

Injection Substation voltage transformers shall be tested in accordance with the provisions of NIS IEC61869-1.

4.2.4.1.3 Current Transformers (CTs)

Current transformers for Injection Substation shall conform with the requirements of NIS IEC 61869-1, 2 and suitable for base mounting on steel channel structure.

Double-ratio current transformers may be of the series-parallel primary type and shall be capable of meeting specified accuracy requirements when operating from the full secondary winding.

Wound type current transformers, other than bar-type primary, shall be equipped with primary bypass devices for protecting the windings against high-voltage surges.

Bushing current transformers shall be of the multi-ratio type.

The insulating materials used for the construction of current transformers shall conform to NIS IEC 60044.

Injection Substation current transformers shall be tested in accordance with the provisions of NIS IEC61869-1, & 2.

4.2.4.1.4 Station Service (Auxiliary) Transformers

For Injection Substations, 33/0.400kV station service transformers shall be installed. The station service transformer shall be of a typical distribution transformer with adequate capacity to meet the auxiliary load requirements of the station.

The station service transformer shall meet the requirements of NIS IEC60076.

The positioning and installation of the station service transformer shall be adequately provided for in the Injection Substation Layout and minimum safety clearance specified in NIS IEC 61936-1 for operations and maintenance shall be observed. The substation service transformers shall be supplying the substation auxiliary services loads from the 33kV incomer

4.2.4.2. Switch Gears

The design, manufacture, assemblage, installation, testing and commissioning of all 33kV and 11kV switch gears in an Injection Substation shall conform to the requirements of NIS IEC 62271 and they shall be capable of continuous operation under a daily average ambient temperature range of 25ºC to 50ºC.

4.2.4.4.4. Circuit Breakers

Switchgears for indoor and outdoor operations shall meet the following conditions as specified below:

4.2.4.3.1. Indoor Circuit Breakers

a) The design, manufacture, assemblage, installation, testing and commissioning of all 33kV and 11kV indoor switch gears shall allow for high voltage testing of the extensible bus-bar section and bays while the other bus-bar section and bays are in operation.
b) All grounding systems, special tools and tackles, operations and maintenance manuals from Original Equipment Manufacturers (OEMs) required for erection, operation, testing, maintenance and commissioning of indoor switch gears for use in Injection Substations shall be provided and shall be in English Language.
c) All indoor switchgear for Injection Substations shall be of the extensible metal clad, compartmentalized, air or gas insulated, and draw out or fixed type complying with the requirements of NIS IEC 62271-200.
d) A set of three phase-insulated bus-bars shall be provided for the switchgear, which shall comply with the requirements of NIS IEC 62271. The busbars shall be clad with

solid insulation. The insulating material used shall be capable of withstanding the heating effects of the rated short time short-circuit current without damage or deterioration.

e) Non-hygroscopic and non-flammable materials shall be used for the manufacture of switchgear equipment and apparatus. Insulating materials for switchgears shall have a high resistance to tracking. Switchgears shall be installed in Injection Substation building with a cable basement and mounted on a concrete floor.

4.2.4.3.2. Outdoor Circuit Breakers

a) The design, manufacture, assemblage, installation, testing and commissioning of all 33kV and11kV outdoor switch gears shall allow for high voltage testing of the extensible bus-bar section and bays while other bus-bar section and bays are in operation.

b) All grounding systems, special tools and tackles, operations and maintenance manuals from Original Equipment Manufacturers (OEMs) required for erection, operation, installation, commissioning, operation and maintenance of outdoor switch gears for use in Injection Substations shall be provided and implemented and used as recommended. Such manual shall be provided in English language.

c) The mounting height of the Circuit Breaker live part shall not be less than 2.5m measured from the plinth level. The operating characteristics shall comply with NIS IEC 62271-100, 200.

d) The circuit breaker arc interrupter unit may be of vacuum, SF_6 gas type or any other approved type based on innovation in technology. The SF_6 breakers using the SF_6 gas shall be handled in accordance with the procedures specified in NIS IEC 62271-4.

e) Circuit breakers manufactured using materials adjudged to be of environmental concern as applicable under the Nigeria Environmental Laws shall not be acceptable.

4.2.4.3.3. Disconnectors/Grounding Switches

a) The design and installation of disconnectors and grounding switches shall be in accordance with the requirements of NIS IEC 62271-102.

b) Disconnectors/Grounding Switches shall be capable of performing the functions of opening and grounding of circuits. No re-strike voltage is allowed under any interrupting conditions.

c) The main blade and grounding switch contacts shall be self-aligning and self-wiping contacts. Fixed contacts shall be capable of preventing contact burning and pitting under fault conditions.

d) The current-carrying path of disconnectors shall not be through any spring. The contacts shall maintain continuous positive contact pressure under closed conditions. The material used for contacts shall be such that there will be no irritation of contact metals after 1,200 open/close switching operations.

e) The blades of Disconnectors and Grounding Switches shall be of good conducting materials or alloy materials for carrying the specified continuous and short-time currents and shall be connected by welding, bolted and riveted if attached to castings.

f) The support or mounting bases of the disconnector switches shall be of galvanized metal members of sufficient strength and stiffness to prevent deflection when mounted and operated on support structures

g) The operating mechanisms of the disconnectors and grounding switches shall be capable of effecting a smooth and thoroughly controlled movement throughout the entire opening and closing cycles. All rods, shafts, pipes linkages, connectors, operating levers, supports and fittings shall show no noticeable stress and deflections.

h) Disconnectors and grounding switches shall be provided with embossed- or stamped-metal indicators on the vertical operating rod showing when the switch is open or closed. The indicators shall be approximately 250 mm high and 30 mm wide, the “closed” indicator painted red and the “open” indicator painted green. The indicators shall be mounted at normal eye level and positioned so that the appropriate indicator directly faces the operator when he is in a normal position for operating the switch.

i) The non-current carrying part of the disconnectors shall be solidly earthed as well as the grounding switches.

4.2.4.3.4. Bypass Isolators

a) Protective devices shall be installed for electrical safety in accordance with the requirements of NIS IEC 62128-1, 2,& 3.

b) Bypass Isolator shall be installed between the main bus and the reserved bus and / or circuit breakers to allow for safe maintenance without loss of power to the adjourning circuit.

c) All protective devices associated with the bypassed circuit breaker must be transferred to an adjoining circuit breaker in line with the same circuit so as not to leave the circuit unprotected.

4.2.4.3.5. Lightning Arresters

Lightning or surge arrester devices shall be installed to protect all substations, intersection of overhead lines and underground cables from lightning and switching surges. The device shall be effectively grounded at its location in accordance with the requirement of NIS IEC 60099.

4.2.4.3. Compensators

Compensators such as Static VAR Compensator or Dynamic Voltage Restorer shall be installed on distribution network to ensure and guarantee the quality of power supply at locations where the line voltage drop is below the allowable nominal values.

4.2.4.3.1. Static Voltage Ampere Reactive (VAR) Compensators

Static VAr Compensator shall be installed on medium voltage distribution lines and at large industrial load points to compensate for reactive power necessary for power quality improvement of the network in accordance with the requirements of the Distribution Code and NIS IEC 61954.

4.2.4.3.2. Dynamic Voltage Restorers

Dynamic Voltage Restorers or Series Voltage Booster device shall be installed to mitigate against voltage sags, spikes, harmonics and in-voltage variations in accordance with the requirements of NIS IEC 61400.

4.2.4.4. Capacitors

Capacitors shall be installed to compensate the inductance of long distance transmission / distribution lines where the parameters of the line drop below the acceptable nominal value as specified in the Grid and Distribution Codes.

4.2.4.4.1. Shunt Capacitors

a) Shunt capacitors installed in an injection substations shall be indoor/ outdoor. Each capacitor unit shall be designed, rated, manufactured, and tested and shall meet the requirement of NIS IEC60871.
b) Shunt capacitor banks shall be properly fenced out with wire gauze or chain link fence and solidly grounded.

4.2.4.4.2. Series Capacitors

Series Capacitors shall be installed to compensate the inductance of long distance distribution lines where the parameters of the line drop below the acceptable nominal value as specified in NIS IEC 60143-1.

4.2.5 Secondary Equipment

Active switchyards area in the injection substation shall have the following secondary equipment installed:

4.2.5.1. Interposing Current Transformers

Interposing current transformer shall be installed to match the secondary current rating of the protective relay and the measuring instruments where there are differences.

4.2.5.2. Relays

All relays used in Injection Substations shall conform ~~to~~ with the requirements of NIS IEC 60255 series of standards

4.2.5.2.1 discrepancy Relays

Differential relays to provide differential protection within a restricted zone of the power network, shall be installed in all injection power transformers installed within a distribution network of 5 MVA and above.

4.2.5.2.2 Overcurrent Relays

Overcurrent relays shall be installed on all feeders and power transformers in injection substation to protect the network from overload condition and overcurrent fault.

4.2.5.2.3 Earth Fault Relays

Earth Fault Relay devices shall be installed on all feeders and power transformers in injection substation to protect the network from all earth or ground fault.

4.2.5.2.4 Buchholz Relays

Buchholz Relay devices shall be installed primarily to protect Injection Substation power transformers from internal faults.

4.2.5.2.5 High Impedance Fault Detection Relays

Undercurrent relay shall be installed on all feeders and power transformers in injection substation to protect the network from high impedance fault conditions as specified in NIS IEC 60255-151.

4.2.5.3. Control Panels

Control panels housing the relays, control and signal devices shall be installed within the control room of the Injection Substation. Control Panel shall be installed at a minimum distance of 1.0m from any obstacle or surrounding walls for easy access, protection scheme installation and maintenance.

4.2.5.3.1 Display Units

Display units shall be such that it is sufficient to indicate all switchgear status, power flow on-line, annunciator alarms, protection relay operations, with active visual and audible alarm systems.

4.2.5.3.2 Insulation Mat

High voltage insulation mat conforming to the requirements of NIS IEC 61111 shall be provided and laid in front of the switch gear panel for the safety of the operators during switching operations

4.2.5.4. Substation Automation

Substation Automation shall include the installation of Intelligent Electronic Devices (IED) and appropriate computer software for the monitoring, protection, control, and metering of distribution network.

Distribution networks shall be designed, operated and maintained to allow for interoperability of substation automation devices in accordance with the requirements of NIS IEC 61850.

4.2.5.4.1. Communication Equipment

a) Effective communication shall be established between each Injection Substation and the Control Centre of the Distribution Company.
b) Communication equipment to be installed shall be such that can interface with the substation IEDs to acquire data to determine the operation status of each IED, support standard protocol to enable the substation integration and maintenance.
c) All communication equipment at each Injection Substation shall be capable of recording and retrieval of network data in accordance with the requirements of the Grid and Distribution Codes.
d) All Radio Communication, Communication Towers and Antennas used in Injection Substations, shall comply with the requirements of the Nigerian Communications Commission.

4.2.5.5. Battery Banks and Battery Chargers

Battery Banks and Battery Chargers shall be properly stacked and installed in a separate adjoining room to the control room. Air extractor fan or Air conditioners shall be installed where the battery Banks and Battery Chargers are installed.

4.3 Health, Safety and Environment

4.3.1. Conveniences and Bathrooms

Conveniences and Bathrooms shall be provided within the premises of all manned substations to ensure personal hygiene in accordance with the requirements of the Nigerian Electricity Health and Safety Code.

4.3.2. Water Supply

Potable water supply shall be made available in all manned substations.

The source of the potable water supply shall be separated from the wastewater collection point by a minimum distance of 5.0m.

4.3.3. Emergency and Standby Systems

Equipment for emergency and standby system including generators, standby emergency lighting, fire extinguishers, first aid box, first aid treatment chart, and flashlights shall be provided for the smooth operation and maintenance of Injection Substations.

Well marked emergency signs, exits and fire muster points shall be provided in accordance with the requirements of the Nigerian Electricity Health and Safety Code.

4.3.3.1. Substation Standby Generator(s) and Mobile Generator Sockets

Substation standby generators or other renewable energy sources shall be of sufficient capacity to cater for the operation of equipment installed at an injection substation with associated extendable socket outlets.

4.3.4. Disposal of Pollutants

Pollutants and their by-products generated in the course of Injection Substation operation shall be disposed of in accordance with the requirement of applicable Nigeria Environment Laws

4.3.5. Switchyard Illumination

Switchyard illumination shall be designed for normal and emergency lighting operations. A minimum illumination level of 100 lux shall be provided within the main switchyard area.

4.3.6. Electrical Hazards

Substation equipment and associated accessories shall be designed, installed, operated and maintained to eliminate electrical hazards in accordance with the requirements of the Nigerian Electricity Health and Safety Code.

4.3.7. Fire Fighting and Protection Equipment

Substations shall be equipped with fire fighting and protection equipment to ensure the safety of personnel and equipment installed in accordance with the requirements of the Nigerian Electricity Health and Safety Code.

Personal Protective Equipment (PPE) shall be provided for substation Operators and any persons making authorized entry into substations in accordance with the requirements of the Nigerian Electricity Health and Safety Code.

Chapter 5: Distribution Network

5.1 General

Distribution Network Standards and Specifications outline compulsory procedures and practices necessary for safe workspace for persons working on Nigeria's distribution network. It is the responsibility of all persons involved in network construction, operations and maintenance to ensure that safe work methods are employed and that statutory requirements are met. In this context, all electrical works shall be designed to be safe for the electrical conditions likely to be experienced during service and the physical environment in which they will operate, taking into account foreseen and unforeseen risks likely to be encountered.

Distribution networks shall consist of;

1. 33kV networks
2. 11kV networks
3. 400V and 230V networks

a. *Materials:*

All materials used for electrical works, their components, accessories and support structures shall be such as to ensure safe operational performance within the anticipated life span of the installation.

b. *Environmental Issues:*

The design, construction and installation of electrical works shall take into consideration environmental issues and concerns, which include but not limited to:

i. The promotion of energy efficiency,
ii. The social impact of new projects, and community concerns,
iii. The minimization of environmental damage, including visual impacts, tree and forestry management programmes,
iv. The consideration of Electromagnetic radiation.
v. Erosion prone environment.

c. *Thermal Ratings*

The thermal capacity of electrical works shall be sufficient to pass the electrical load for which they are designed, without reduction of electrical and mechanical properties to a level below that which provides safe operational performance.

d. *Short Circuit Ratings*

The electricity works shall be of sufficient capacity to pass short circuit currents, which will enable the correct operation of protective devices so that a fault is cleared without reduction of electrical and mechanical properties to a level below that which provides safe operational performance.

e. *Mechanical Loading Conditions*

The electrical works shall have sufficient mechanical and structural strength to withstand anticipated stresses and strains due to environmental and electrical service conditions.

f. *Electrical Service Conditions and Physical Environment*

In determining the electrical service conditions and the physical environment under which the electrical works will operate, reasonable care shall be given to the consideration of extremes that may occur, the likelihood of their occurrence and the associated risks.

g. *Prevention of Unauthorized Access*

All electrical works with exposed live parts shall be designed and constructed in such a manner as to prevent unauthorized access to any person as far as is reasonably practicable.

5.1.1. Route Surveys

a. Pole line surveys – A survey shall produce a plan and profile of the surveyed route. The plan shall show the route the line will follow and the significant topography adjacent to the route. The profile shall show the ground elevation along the line and the top elevations of the poles. These elevations shall be set in accordance with minimum allowable clearances specified in Clause 5.2.3 of these Regulations.
b. Poles for distribution lines shall be placed on the side of the streets that is most free of other lines and trees. A distance of 45 m shall be maintained between adjacent poles up to a maximum of 50 m where it becomes difficult to maintain the statutory distance between poles. Long roads, poles shall be placed at a minimum distance of 1.5 m from the inside edge of the kerbs or 1.5m from the edge of the road surface where kerbs do not exist. On open roadways or highways, poles should be set at 0.45 m from the outside of fences.

5.1.2. Engineering Designs

All engineering designs shall be carried out, certified and approved by qualified COREN Registered Engineer(s).

Engineering designs of overhead distribution lines shall also take into consideration the following;

i. Compliance with Statutory Regulations
ii. Safety of equipment, employees and the general public
iii. Economic utilization of materials
iv. Conformity with international best practices that meet the need of users with minimum environmental impact
v. Conform to acceptable standards, both from an engineering point of view and aesthetics.

5.1.3. Design of overhead distribution lines shall also allow for;

i. Weight of conductor and fittings
ii. Conductor tension
iii. Terminal load
iv. Deviation loads
v. Differential conductor loads in adjacent spans
vi. Vertical loads
vii. Stay loads
viii. Environmental Loads (eg. Wind and dust) on Structures and Conductors

5.1.4. Conductor Clearance: - to ground, to roads etc

i. To railway lines
ii. Over flood country
iii. To building
iv. Over Other lines

5.1.5. Topography of Terrains and Avoidance of obstructions

i. Airfields
ii. Roads
iii. Railway lines
iv. Telecom lines
v. Stays
vi. Special exclusion areas

5.1.5.1. Materials and accessories

Materials and accessories for overhead line construction shall be designed to meet all the electrical and mechanical loads likely to be experienced in service as far as reasonably practicable in accordance with the relevant clauses of these standards.

5.1.5.2. Selection of Insulators

a. The following factors specified in NIS IEC 62068 shall be considered in the selection of the appropriate insulation of overhead lines:
   i. 50Hz performance
   ii. Lightning impulse withstand capabilities
   iii. Switching and voltage stresses capability
   iv. Tensile strength
   v. Mechanical strength to bear the conductor load
   vi. Resistance to temperature changes
b. For design purposes, the average minimum and maximum ambient temperatures shall be 20°C and 45°C respectively.
c. Unless otherwise authorized by the Commission in writing, the following working conditions shall be assumed for design purposes-
   i. Minimum ambient temperature of overhead line conductors … 20^{o}C
   ii. Maximum temperature of overhead line conductors …………. 100^{o}C
   iii. Average ambient temperature of overhead line conductors …… 45^{o}C

iv. For all design purposes the reference temperature shall be the minimum temperature of 20^oC

5.1.5.3. Stay Insulators

The stay insulators shall be mounted not less than 2.7m vertically above ground and have a wet power frequency flashover voltage not less than one and a half times the highest voltage conductor supported by the pole.

5.1.5.4. Conductor Sag

a. The sag for overhead distribution lines, which is the vertical distance between the point where the line is joined to the support structure and the lowest point on the line, shall be parabolic in shape.

b. Clearances must also be observed when stringing a line. The normal clearances for overhead lines are as shown in the Table 5.1.5.4 below.

Table 5.1.5.4

Voltage Level	Clearance to Ground
11 kV	7.2 m
33 kV	8.1 m
132 kV	18.0 m
Greater than 132 kV	37.0 m

5.1.5.5. Cross - Arms

Cross arms shall be fiber, treated opepe wood or steel constructed. The mechanical loads to which cross arms may be subjected shall take into consideration the conditions likely to be experienced in service so as to minimize the probability of failure. Untreated Opepe wood, treated or untreated other type of wood shall not be used as cross-arm.

5.1.5.6. Design Load Consideration on Cross Arms

Cross arm design for single supports shall be treated as two cantilevers fixed at the support. The cross arm shall be capable of withstanding the following;

a) Bending moment due to span weight of the conductor.
b) Bending moment due to transverse conductor loads - wind and deviation loads acting at top of insulator.
c) Bending moment due to direct horizontal pull of conductors (termination or strain and stress structures only).
d) Maintenance loads resulting from additional conductor lowering or anchoring activities.
e) The weight of the cross arm
f) Kingbolts shall also be checked for allowable bearing loads. Cross arm brace bolts shall be checked for allowable bearing loads at an angle. Cross arms shall also be selected to give the required separation on the support and at mid-span.

5.1.5.7. Civil Works

5.1.5.7.1. Temporary Access Roads

Where it is impossible to route the distribution overhead line through existing access roads and highways, temporary access road shall be created to facilitate line survey and construction. Licensee shall comply with relevant applicable way leave Regulations in force.

5.1.5.7.2. Pole/Tower Foundations

Pole/tower foundations shall take into consideration the local soil properties and requirements as a decisive factor in ensuring high continuity of service, long life of equipment and low maintenance costs.

The foundation shall be so constructed taking into account the reaction of the soil at all times of the year in which they are planted for the load they are to carry so as to withstand the transverse, horizontal and vertical loads without exceeding the material strength limits set out in the factor of safety requirements.

Pole foundation depth shall comply with the NIS 586:2020 standards set in the Table 5.1.5.7.2

Table 5.1.5.7.2

S/N	Pole/Tower Length in (m)	Pole/Tower Depth (m)
3	8.54	1.5
4	10.36	1.7
6	12.2	2.0
10	18.36	3.1

Poles planted along sandy, swampy and clay soils shall in addition, have concrete bases with a depth of 0.8 m below ground level and 0.6 m above ground level.

Towers shall be applicable in distribution overhead lines construction under special conditions, which may be bordering on the terrain and topography of the surveyed route. The foundations of the poles and towers shall be constructed, based on the results of geotechnical investigation tests conducted along the defined routes.

5.1.5.7.3. Support Structures for Distribution Lines.

a. Every support carrying electric lines shall be made of wood, steel or reinforced concrete or any combination of such materials or any other approved materials and in the case in which wood or steel is used in the construction of the support, such wood or steel or any other approved materials shall be, so far as is reasonably practicable, protected against decay, corrosion or other deterioration.
b. Every support shall be so constructed and placed as to withstand the transverse, horizontal and vertical loads calculated while taking into consideration, the appropriate wind pressure along the height of the support structure above ground level. In accordance with 5.1.5.7a without exceeding the material's strength limits as set out in 5.1.5.7.4b.
c. In no case shall the strength of a support in a direction parallel to the overhead line be less than one quarter of the strength in a direction transverse to the said line.
d. All overhead electric lines shall be attached to suitable insulators carried on cross-arms or brackets of suitable materials and cross-section, and they shall be so attached to the insulators, or guarded, that they cannot fall away from the supports in case they become detached from the insulator, but will fall on the cross-arm or insulator support.
e. All lines at angles shall be attached to the insulator so that the insulator, and not the binding wire, takes the strain.

5.1.5.7.4. Load Bearing Capacity for Support Structures of Distribution Lines and Safety Factor

a. The transverse load on any support carrying an electric line shall be calculated in accordance with its average height above ground level throughout its span, and the wind pressure on the leeside of lattice steel or other compound structures shall be deemed to be one half of the pressure on the leeward side. The vertical loads on supports shall comprise the weight of the supports themselves and any insulators and fittings attached thereto, together with the loads imposed by the electric lines and their fittings.

b. **Factors Of Safety**

   Overhead electric line supports, in conjunction with stays and struts if provided, shall withstand the longitudinal, transverse and vertical loads due to fittings, conductors and wind loadings under the most adverse temperature conditions and with the factors of safety specified in Table 5.1.5.7.4 below:

Table 5.1.5.7.4

	Line Specification	Factor of Safety
(a)	Live and earth conductors, based on the ultimate tensile strength of the material	2.5
(b)	Mid-span joints and termination based on the ultimate tensile strength of the conductor (comparative safety factor between the ultimate tensile strength of the mid-span joint and the ultimate tensile strength of the conductor)	0.95
(c)	Complete insulator units based upon the electro-mechanical strength of the material (comparative safety factor between the ultimate tensile strength of the insulator string and the ultimate tensile strength of the conductor)	0.5

(d)	Stay wires and auxiliary materials based on ultimate tensile strength	2.0
(e)	Insulator metal fitting based upon elastic limit	2.5
(f)	Lattice steel supports (or other compound structures) based on the crimping load of members in compression, the elastic limit of members in tension and the shear or bearing deformation at joints	2.0
(g)	Steel tubular poles based on the ultimate breaking strength in handling of the material	2.0
(h)	All types of concrete poles based on the strength corresponding to failure	2.5
(i)	Foundation for supports against overturning lateral shearing, toe compression and uprooting under maximum simultaneous working loads based on soil bearing strength	2.5
(j)	Under a single broken electric line or earth wire condition the factors of safety for supports and foundations shall not be less than	i. Support: 50% of the factors of safety given under items F TO H above ii. Foundations: 50% of the factors of safety given in item I above

5.1.5.7.5. Reinforcement for Support Structures of Distribution Network by Guy Assembly

Overhead line supports at locations where the loads exceed the capacity of the poles/foundations shall be stayed so that the stay wire, rod, bed, log/screw anchor etc take the pull due to the conductors.

a. Stay wires connected to wooden supports carrying electric lines of all voltages, and also stay wires connected to concrete supports carrying electric lines at 400 volts or less shall be insulated to prevent danger from leakage. For this purpose, an insulator of the same or greater rating as the insulator supporting the electric lines, shall be inserted in the stay wire not less than 3.0 m vertically above ground and below the level of the electric line.

b. Stay wires connected to steel supports or any other supports made of an electrically conducting material shall be insulated.

c. Where a stay wire crosses over a road or street a minimum distance of 5.8 meters to ground level shall be maintained.

d. All stay wires shall be of galvanized steel and stranded.

e. Stay insulators shall have a mechanical strength equal to or greater than that of the stay in which it is installed.

f. Where a stay wire is installed in a public place or in any other location in which it may constitute a hazard, it shall be: –

i. Effectively protected against mechanical damage by the installation of a concrete surround; or

ii. Covered with a protective guarding consisting of metal battens at 50mm wide, or a metal pipe at least 50mm in diameter, securely fastened around the stay wire and extending from ground level to a point not less than 2.0m vertically above ground level. The concrete surrounds and the protective guarding shall be painted white.

5.1.6. Allowable Voltages for Distribution Network

The distribution network shall be operated on voltages as defined below:

i. **Systems of Supply**

The following system standards shall apply–

a. Frequency – The frequency shall operate within a narrow operating band of ± 0.5% from 50Hz (49.75 – 50.25 Hz); but under System Stress, the Frequency on the Power System could experience variations within the limits of 50 Hz ± 2.5% (48.75 – 51.25 Hz).
b. Standard A.C. voltages – shall be 230 V ± 6% between phase conductor and neutral conductor and 400 Volts ± 6% between phases conductor; Primary distribution high voltage shall be 33,000 Volts ± 6% and secondary distribution high voltage shall be 11,000 Volts ± 6%;

ii. **Standard Types of Supply**

a. Two-wire system (single-phase alternating current) at a nominal voltage not exceeding 230 volts at the user's main switchboard.
b. Three-phase four-wire alternating current system at a nominal voltage not exceeding 400 volts between phases
c. The voltage shall be maintained within ±6% of the nominal voltage at the consumer's main switchboard. In the case of complaint by any consumer that the variation in voltage exceeds the limits specified, or on the instructions of NEMSA, the Distribution licensee shall provide, connect and maintain a portable recording device to record the voltage profile between the service line and the energy metering device (meter). If the variation thus recorded are outside the limits and caused by the licensee's system, the licensee shall take immediate steps to resolve the complaint.
d. This Regulation shall also apply to Captive Generation Licensee.

iii. **Supply Voltage**

a. Supply voltage shall not exceed 230 volts at the user's main switchboard, and for supply to services exceeding 10 kilowatts connected load the nominal voltage shall not exceed 400 volts at such switchboard.
b. The Supply Voltage for industrial purposes may be given at high voltages either for transformation or for direct supply to motors or any other agreed voltage between the Distribution Licensee and the user. This shall be subject to the standard voltage in these Regulations provided that the transforming apparatus and control gear are so enclosed as to be inaccessible except to authorized persons.

5.1.7. Insulation Requirements for Distribution Network

Distribution Network shall be appropriately insulated to guarantee safety of equipment and personnel. Insulation materials used shall be capable of withstanding high insulation value(s) throughout the service life of the equipment or installation. Provisions of **NIS IEC 62068** on insulation of equipment, materials and installation shall be adhered to.

5.1.8. Earthing of Distribution Network

All electrical installations and network shall be adequately earthed to guarantee operational safety as specified in the Code of Practice for Earthing (NCP 09). Chapter 11 details earthing in electricity supply and installations.

a. *Earthing of Metal Structures*

i. Where lines are operated at high voltages, all metal structures, other than current carrying conductors shall be permanently and effectively connected to earth electrode(s). For this purpose, a continuous earth wire shall be provided and connected to earth.

ii. Where any special equipment on a pole includes metal structure accessible from ground level which normally has to be handled by an operator when the line is alive (e.g. a switch-operating handle), such metal structure shall be connected to an earth mat, so situated as to include within its area the whole of the ground on which the operator would normally stand.

b. *Earthing at Pole - Mounted Substations*

For Pole mounted transformer, the electrode used for earthing the steelwork shall be situated outside the resistance area of the earthed electrode connected to the low voltage neutral.

5.1.9. Equipment and Installation Devices for Distribution Network

All materials, equipment, devices and accessories used directly in construction, installation and maintenance of distribution network shall constitute electrical network equipment and installation devices. They shall include, but not limited to

i. Support structures; Metal or re-enforced concrete poles, gantry, guy, stay assembly
ii. Overhead materials; Conductors, insulators, line hardware, accessories;
iii. Underground materials; Cables, termination kits, lugs;
iv. Substation equipment; Transformers, shunt capacitors, arresters, feeder pillars.

5.2 Overhead Distribution Lines

5.2.1. General

Overhead Distribution Lines shall be constructed with non-insulated and insulated conductors on supports designed and constructed to:

a. Have insulation appropriate for the nominal voltage,
b. Carry the electrical load currents for which they are designed,
c. Allow the passage of electrical short circuit currents which will enable the correct operation of protective devices,

d. Ensure they are structurally secure for the environmental and service conditions for which they were designed,
e. Maintain safe clearances,
f. Ensure that safe operational performance will occur, and
g. Prevent unauthorized access to the electrical works.

5.2.2. Routing of Overhead Lines

Overhead line routes shall be planned bearing in mind the type of use, or foreseeable use, to which the land is or may be put to use subject to extant town planning Laws.

5.2.3. Highway Routes

5.2.3.1. At highways, it is required that a minimum ground clearance of 7.2m is maintained in order to accommodate vehicles up to 6.1 m height.

5.2.3.2. In planning an overhead line likely to cross a major road, it shall be established whether or not it is a designated highway route or a possible bypass to a highway route, the Utility shall take into consideration and specify the clearance appropriately.

5.2.4. Overhead Lines with Bare Conductors

Where overhead lines with bare conductors are routed across sites used for public recreation and work activities other than farming, they shall be protected with cradle guards.

5.2.4.1. Routing Overhead Lines across Farmlands

A risk assessment shall be carried out and any unacceptable location shall be avoided. Examples include:

i. Locations where regular loading /unloading activities take place
ii. Fields where potable irrigation pipes are regularly used
iii. Any location identified as being a potential hazard to farm workers

5.2.4.2. Pole Mounted Transformers and Switchgears

i. Live jumpers may be as low as 4.3 m from ground level. Such equipment shall be placed where accidental contact is adjudged to be unlikely.
ii. Free standing pole mounted transformers shall not be used at locations considered unsuitable for overhead line and are unlikely to be suitable for low level exposed live terminals. In event of changing the original use of the location of a pole mounted transformer, the pole mounted transformer shall not be retained as free-standing transformer unless it is clear that the new use of the land does not place persons at risk.

5.2.5. Vehicular Access

5.2.5.1. Overhead lines shall be constructed along routes accessible to 4-wheel drive vehicles and a safe access-provided for tall structures. The access shall be suitable for mobile elevated work platform and ladders with a minimum clearance of 7.2 m

5.2.5.2. Where bare overhead lines present a risk, the following alternatives shall apply in order of preference with appropriate insulation

a. Underground Cables
b. Insulated Conductors.

5.2.6. Line Conductors

5.2.6.1. The conductors used on overhead lines shall include, but not limited to, aluminium and alloys of aluminium material (essentially AAC, ACSR) designed to withstand the electrical and mechanical loads over the designed operational life, without failure. Classes and qualities of aluminium conductors applicable in distribution overhead network shall comply with the provisions of NIS IEC 61089. Copper line conductors shall be used for maintenance purposes only where copper lines already exist. Copper conductors will, however, continue to be required for special purposes such as drop leads to equipment, earthing.

5.2.6.2. The use of AAC and ACSR on overhead distribution network operating at 11 kV and above shall be limited to their current and thermal loading capacities in addition to safety considerations to avoid the consequence of snapping. The minimum cross-sectional area of such conductors shall be 100 mm^2.

5.2.6.3. The size of the neutral conductor shall not be less than that of phase conductor. The street lighting switch conductor shall be $35mm^2$ (2.65mm) Aluminium or $25mm^2$ (7/2.34mm) hard drawn copper.

The PVC insulated conductors shall comply with NIS 359.

5.2.7. Handling of Electric Supply Lines and Apparatus: -

5.2.7.1. Before any conductor or apparatus is handled, adequate precautions shall be taken, by earthing or other suitable means to electrically discharge such conductor or apparatus, and any adjacent conductor or apparatus if there is danger therefrom.

5.2.7.2. Every person who is working on an electric supply line or apparatus or both shall be provided with Personal Protective Equipment (PPE) in accordance with the Nigerian Electricity Health and Safety Code.

5.2.7.3. No person shall work on any live electric supply line or apparatus and no person shall assist such person on such work, unless he is authorized in that behalf, and takes the safety measures approved by the extant Regulations.

5.2.7.4. Every telecommunication line on supports carrying a high or extra-high voltage line shall, for the purpose of working thereon, be deemed to be a high voltage line.

5.2.8. Strength of Material

5.2.8.1. All conductors of overhead lines shall have a minimum breaking strength as specified in NIS IEC 61089.

5.2.8.2. Where the voltage is low and the span is of less than 15 metres and is on the owner's or user's premises, a conductor having an actual breaking strength as specified in NIS IEC 61089 may be used.

5.2.9. Arrangements

5.2.9.1. In the network where street lighting switch wire is not required, the normal arrangement of conductors for a three phase, 4-wire line from top to bottom shall be as follows:

Red Phase	No. 1
Yellow Phase	No. 2
Blue Phase	No. 3
Neutral	No. 4

5.2.9.2. Where street lighting is required, this shall occupy position No. 4 and the neutral shall be placed in a fifth position below the switch wire. If the switch wire is not to be erected initially, position No. 4 shall be left vacant. For a single phase, two wire line, position No. 3 and 5 shall be used. Two-phase three-wire construction is not permissible, and shall be avoided in the design of new overhead networks.

5.2.9.3. In special circumstances, it may be necessary to adopt a horizontal conductor formation over a short distance in which case the above numbering shall apply from left to right when looking towards the source of supply.

5.2.10. Properties of Distribution Conductors

5.2.10.1. Distribution conductors shall consist of standard bare conductors of round strands helically laid about a core in one or more layers. The core shall consist of a single strand identical to the outer strands and are of the same diameter in a homogeneous conductor as in – All Aluminium conductor (AAC), hard drawn copper (CU), or All Aluminium Alloy Conductors (AAAC).

5.2.10.2. In non-homogenous conductor as in Aluminium Conductor Steel Reinforced (ACSR), Aluminium Conductor, Aluminium Alloy Reinforced (ACAAR), the strands in the core may or may not be of the same diameter.

5.2.10.3. The rated breaking strength of the conductors shall be capable of withstanding the mechanical loading without undue sagging within acceptable temperature limits and other adverse weather and environmental conditions they shall be subjected to during their service years.

5.2.11. Load Bearing Capacity for Overhead Distribution Lines and Safety Factors

Overhead distribution lines shall have capacity capable of withstanding loading due to:

i. Designed current capacity within its temperature threshold;
ii. Weather conditions such as wind, ambient temperature, solar radiation, rain and storm
iii. Mechanical loading (line tension without undermining voltage-specific ground clearance)

5.2.11.1. Factor of Safety

Overhead electric line supports, in conjunction with stays and struts if provided, shall withstand the longitudinal, transverse and vertical loads due to fittings, conductors and wind loadings under the most adverse temperature conditions and with the factors of safety herein under specified-

Table 5.2.11.1: Factor of Safety

Condition	Factor of Safety (not less than…)
Live and earth conductors, based on the ultimate tensile strength of the material	2.5
There shall be one (1) joint only for new connections; while two (2) joints may be allowed for existing connections. Any exceptions shall be referred to NERC for approval in case of emergency. Mid-span joints and termination based on the ultimate tensile strength of the conductor (comparative safety factor between the ultimate tensile strength of the mid-span joint and the ultimate tensile strength of the conductor)	0.95
Complete insulator units based upon the electro-mechanical strength of the material (comparative safety factor between the ultimate tensile strength of the insulator string and the ultimate tensile strength of the conductor)	0.5
Stay wires and auxiliary materials based on ultimate tensile strength	2.0
Insulator metal fitting based upon elastic limit	2.5
Lattice steel supports (or other compound structures) based on the crimping load of members in compression, the elastic limit of members in tension and the shear or bearing deformation at joints	2.0
Steel tubular poles based on the ultimate breaking strength in handling of the material	2.0
Impregnated wood poles in accordance with Nigerian Standard No. 43 based on 90% of the strength corresponding to the ultimate extreme fibres stress or for poles supported with stays 90% of the crippling strength	3.5
Impregnated wood poles in accordance with Nigerian Standard No. 43 and supported with stays based on 90% of crippling strength	3.5
All untreated poles based on 90% of the strength corresponding to the extreme fibre stress	7.0
All untreated poles supported with stays based on 90% of crippling strength	7.0
All types of concrete poles based on the strength corresponding to failure.	2.5
Foundation for supports against overturning lateral shearing, toe compression and uprooting under maximum simultaneous working loads based on soil bearing strength	2.5
Under a single broken electric line or earth wire condition the factors of safety for supports and foundations shall not be less than i. For Support: 50% of the factors of safety given in Regulations 5.2.11.2 (a) (i) to (iv); ii. For Foundations: 50% of the factors of safety given in 5.2.11.2 (a) of this Regulation.	

5.2.11.2. Minimum Factors of Safety for Metal Structures

a) The following minimum factor of safety shall apply;

i. For metal supports, 1.5
ii. For mechanically processed concrete supports, 2.0
iii. For hand-moulded concrete supports, 2.5
iv. For wood supports, 3.0.

b) The minimum factor of safety shall be based on such load as would cause failure of the support to perform its function (assuming that the foundation and other components of the structure are intact).

c) The aforesaid load shall be;

i. Equivalent to the yield point stress or the modulus of rupture, as the case may be, for supports subject to bending and vertical loads,
ii. The crippling load for supports using struts.

5.2.11.3. Minimum Factors of Safety for Wires and Conductors

Provided that in the case of latticed steel or other compound structures, factors of safety shall not be less than 1.5 under such broken wire conditions.

a. The minimum factor of safety for stay-wires, guard-wires or bearer wires shall be 2.5 based on the ultimate tensile strength of the wire.
b. The minimum factor of safety for conductors shall be 2, based on their ultimate tensile strength. In addition, the conductors' tension at 32^{o}C without external load, shall not exceed the following percentages of the ultimate tensile strength of the conductor: -

Initial unloaded tension:	35 per cent
Final unloaded tension:	25 per cent

5.2.12. Jointing Requirements for Overhead Distribution Conductors

Joints between conductors of overhead distribution lines shall be mechanically secure and electrically continuous under the conditions of operation. The ultimate strength of the joint shall not be less than 95 per cent of that of the conductor and the electrical conductivity not less than that of the conductor. There shall be one (1) joint only for new connections; while two (2) joints may be allowed for existing connections.

5.2.13. Dielectric Strength of Insulators of Overhead Distribution Lines

Insulators used in the distribution network shall be of high grade devoid of impurities and have insulation/dielectric strength that shall suffer minimal adverse effect when exposed to:

i. Homogenous and non-homogenous electric field
ii. Mechanical stress

iii. Chemical effects
iv. Conductor surface effects (flash-overs)
v. Other ambient effects like pressure and temperature

The Insulators shall meet the requirements of NIS IEC 60071-2. The minimum acceptable failure rate of the insulators shall be 0.004/year for apparatus and 20/100km/year for distribution lines.

5.2.14. Guard Lines, Guard Nets and Protective Devices

Cradle guards, guard nets, earth bars and protective devices shall be installed where necessary in accordance with Clauses 5.2.15 to 5.2.18 below. The cost of such installation shall be borne by the last service provider to arrive at the point.

5.2.14.1 Electric Lines Crossing Waterways

a. The height of an electric line under the most adverse operating conditions, above the highest recorded water level, over harbours, rivers and waterways, shall not be less than that required by the appropriate authorities for physical safety clearance PLUS a minimum electrical safety clearance of 3 metres, or 1 metre per 78 kV of phase to neutral voltage of the electric line, whichever is greater.

b. The licensee shall have at least thirty days and not more than ninety days prior to the placing of such work serve written notice on the appropriate authorities specifying the intended use of the works, the voltage of operation and such other information that the authorities may require him to supply.

c. Every notice served in conformity with Clause 5.2.14.(b) shall be accompanied by a plan of suitable scale indicating the site of the crossing, the location of all supports, stays, struts, switches, transformers and other apparatus intended to be used.

d. The authorities may within 21 days of the receipt of such a notice of intention served under Clause 5.2.14(b) serve a counter notice on the licensee —

i. No objection
ii. Objecting to the siting of the works specifying the reason in the counter notice; and requiring protective features to be fitted, such features to be specified in the counter notice requiring protective features to be fitted, such features to be specified in the counter notice.

5.2.15. Proximity to Railway Lines

The provision of Clauses 5.2.14(b) to 5.2.17 shall apply where the licensee intends to place an electric line, other than a service line, in the proximity of, over or under a railway line.

5.2.16. Proximity to Telecommunication Lines

a. The provision of Clause 5.2.14(b) to 5.2.17 shall apply where the licensee intends to place an electric line, other than a service line, in the proximity of, over or under telecommunication lines or other services.

b. Other than in the case of a fully insulated services line all electric lines, except with the written authority of the Commission, shall cross over telecommunication lines with a minimum clearance, under the most adverse operating conditions at the point of crossing, as shown in Table 5.2.17

Table 3-a

System Voltage between Phases	Clearance (Metres)
Not exceeding 400 volts – insulated	0.2
Not exceeding 400 volts - un-insulated	0.6 -
Over 400 volts but not exceeding 33,000 volts	1.8
Over 33,000 volts but not exceeding 132,000 volts	2.4
Over 132,000 volts but not exceeding 330,000 volts	4
Over 330,000 volts but not exceeding 750,000 volts	7

c. So far as may be practicable the licensee shall leave one side of each street free for telecommunication line and where the street is continuous the licensee's line shall be kept to the same side of the street for the whole distance.
d. Except with the permission of the NCC all overhead lines shall be placed on the opposite side of the street to that on which any telecommunication lines are erected, and where the erection or operation of the electric lines necessitates an alteration of an existing telegraph lines, and such alteration is approved by the NCC, the expense of the alteration shall be borne by the licensee; provided that where existing communication lines of the Telecommunication Providers occupy both sides-of the street that Telecommunication Provider shall bear the cost of putting all communication lines on the one side of the street or if agreeable to the licensee, consent to an arrangement for the joint use of poles on both sides of the street.
e. Where electric lines are on one side of the street and telecommunications lines on the other, and service is required to be given from either side to the other, the licensee and the communications company shall give to each other reasonable facilities as far as possible to effect supply. Where possible electric service lines, unless fully insulated, shall pass over telecommunication lines.

5.2.17. Proximity To Airfield

The provision of Clauses 5.2.14(b) to 5.2.17 shall apply where the licensee intends to place an electric line in the proximity of an airfield.

5.2.18. Proximity to Radio, Television, or Telecommunication Aerials

5.2.18.1 Radio and Television

The provision of Clauses 5.2.14(b) to 5.2.17 shall apply where the licensee intends to place an electric line, other than a service line, in the proximity of a radio or television aerial.

5.2.18.2 ***Cradle Guards, Guard Nets and Other Protective Devices***

Cradle guards, guard nets and protective devices shall be installed in accordance with the provisions of Clause 5.2.14. The cost of such installation shall be borne by the last service provider to arrive at the point.

5.2.18.3

Where guarding is required under these rules the provisions of sub rules 5.2.19.1 and 5.2.19.2 shall apply:

i. Every guard-wire shall be connected with earth at each point at which its electrical continuity is broken.
ii. Every guard-wire shall have an actual breaking strength of not less than 635kN or kg and if made of iron or steel, shall be galvanised.
iii. Every guard-wire or cross-connected systems of guard-wires shall have sufficient current-carrying capacity to ensure the rendering dead, without risk of fusing of the guard-wire or wires till the contact of any live wire has been removed.

5.3 Basic Clearances for Installation on Distribution Lines

The basic clearance for the installation on distribution line shall be as provided below:

5.3.1 Height of Overhead Distribution Conductors

5.3.1.1 ***Electric Line Clearance to Ground***

a) The height above ground of any electric line under the most adverse operating conditions shall not, except with the written authority of the Commission, be less than the height appropriate to the system voltage and situations tabulated in Table 5.3.1.1

Table 5.3.1.1 (a): Clearance to Ground

Ground Clearance in Metres			
System voltage between phases(V)	*Over streets and roads and public open spaces and other places of vehicular traffic (m)*	*Along streets and roads and other places accessible to traffic(m)*	*Positions inaccessible to vehicular traffic not streets or roads(m)*
400	5.8	5.8	5.8
3,300	6.1	6.1	6.1
6,600	6.1	6.1	6.1
11,000	6.1	6.1	6.1
33,000	6.1	6.1	6.1
66,000	6.1	6.1	6.1
132,000	6.1	6.1	6.1
330,000	6.1	6.1	6.1
750,000	6.1	6.1	6.1

b) Fully insulated service lines operating at a voltage not exceeding 400 volts may be terminated on buildings at a height of not less than 2.7 metres from ground level provided that the street clearance at any point of its span is not less than 6.1 metres.

5.3.1.2 ***Approval in Specific Instances***

Notwithstanding the foregoing, where the specified clearances are not so attainable, the Commission may, in specific instances, authorize the use of reduced clearances subject to such additional safety precautions in the form of warning notices, warning lights or crash barriers, as the Commission may deem necessary.

5.3.2 **Parallel Spacing of Circuits on Separate Supports**

The minimum distance between the nearest conductors of circuits erected on separate supports such that they run along parallel routes shall not be less than that required to enable the safe maintenance of either circuit to be carried out without de-energizing the circuit that is not being maintained, and the horizontal separation shall be greater than the height of the highest support.

5.3.3 **Mid-span Crossing of Electric Lines**

Where electric circuits cross at mid-span positions the following conditions shall apply-

a. the circuit of the higher voltage shall always cross over the circuit of the lower voltage;

b. no circuit shall cross at an angle of less than 30 degrees; and

c. the minimum clearance between the nearest conductors of different circuits at the point of crossing, including "aerial" earth wire, shall not be less than that tabulated in table 5.3.3.3 below plus the maximum design sag of the conductor of the lower circuit at the point of crossing;

Table 5.3.3.(a)

Lower Circuit (Voltage between phases)			***Upper Circuit (Voltage between phases)***			
	Earth wire	**415 V (cm)**	**11,000 V (cm)**	**33,000 V (cm)**	**132,000 V (cm)**	**330,000 V (cm)**
Earth wire	30	20	30	120	120	240
400V	20	120	120	120	180	270
11,000V	30	—	120	—	180	270
33,000V	30	—	—	—	180	270
132,000V	120	—	—	—	230	360
330,000V	230	—	—	—	—	480
750,000V	—	—	—	—	—	—

d. Where the circuit of the higher voltage is fully insulated, the minimum clearance calculated in accordance with the provision of above Table may be reduced by 50%.

5.3.4 **Clearance of Electric Lines to Buildings**

A line may be erected over or adjacent to a building provided that:-

5.3.4.1 Lines Over or Adjacent to Buildings

A line may be erected over or adjacent to a building provided that the radial distance in metres from the point of attachment of the suspension insulator (or conductor if attached to a fixed insulator) of the lower conductor, to any part of the building is not less than the conductor sag at maximum design temperature plus length of suspension insulator string plus “A”, where “A” is a constant dependent on the voltage between phases of the conductors of the line. The Constant A for various voltages is given below:-

Table 5.3.4.1

Voltage Level	*Constant A*
400volts to 11,000 volts	*2.4 m*
33,000 volts	*3.0 m*
132,000 volts	*4.0 m*
330,000 volts	*6.0 m*
Over 330,000 volts	*8.0 m*

5.3.4.2 Fully Insulated Conductors

Where the conductors of the circuit are fully insulated, the constant "A" may be reduced by 50%.

5.3.5 Alternative provisions

5.3.5.1 Failure to Satisfy Provisions of 5.3.4.1

Where the conditions, provided for under the clearance of electric lines to buildings above cannot be met, the line shall be erected so that the minimum horizontal distance in metre of the nearest conductor in still air is not less than the conductor sag at maximum design temperature plus length of suspension insulator string plus “B”, where "B" is a constant dependent on the voltage between phases of the conductors of the line. The Constant B for various voltages is given below:-

Table 5.3.5.1

Voltage Level	*Clearance*
400volts to 11,000 volts	*2.4 m*
33,000 volts	*3.0 m*
132,000 volts	*4.0 m*
330,000 volts	*6.0 m*
Over 330,000 volts	*8.0 m*

5.3.5.2 Failure to Satisfy Provisions of 5.3.4.2

Where the conductors of the circuit are fully insulated, the constant "B" may be reduced by 50%.

5.3.5.3 Ariel Bundle Conductor

In the case of specially designed fully insulated aerial cables, clearance to buildings may be reduced at the discretion of the Commission.

5.3.5.4 Prohibition of Erecting Buildings Under Overhead Distribution Lines

No building or other structure shall be erected under or adjacent to an electric line without adhering to the provisions of these Regulations.

5.3.5.5 ***Flexible conductor covers (line hoses) of insulating material***

5.3..5.5.1 A protective cover is generally designed to provide a required insulation when a worker or external object inadvertently comes into contact with the protective cover and for only a short duration. The deployment of flexible conductor cover in NESI shall be in line with the provisions NIS NIS IEC 61479

5.4. ***Type of overhead Distribution Lines***

5.4.1 This standard covers the design and construction of overhead distribution lines for

i. single circuit overhead 33kV and 11kV distribution lines

ii. double circuit overhead 33kV and 11kV distribution lines

iii. dual circuit overhead 33kV &0.4kV distribution lines

iv dual circuit overhead 11kV & /0.400kV distribution line

v. 0.4kV (low tension) overhead distribution line

5.4.2 all construction of single circuit 33kV and 11kV distribution line shall conform to the provisions of 5.1.3 of this regulation, in addition the following standards shall apply:

a. Where a 33kV and 11kV line crosses a road the height of the electric pole on either side of the road shall be a minimum of 12.2m
b. Where a 33kV and 11kV line crosses a dual carriage way , river of more than 60m wide, and rail crossing a two pole structure shall be constructed on either side and the conductor shall be continuous. The pole shall be galvanised steel.
c. Where a 33kV and 11kV line crosses a dual carriage way, river above 60m but less than 100m wide or rail crossing, a steel lattice structure shall be constructed on either side and the conductor shall be continuous
d. Where a 33kV and 11kV line crosses a dual carriage way, river above 100m wide, a mid-span interposing tower shall be constructed on either side and the conductor shall be continuous.
e. Where a 33kV and 11kV line crosses a road, the conductor shall be continuous within a span.
f. The span of 33kV and 11kV network for inter township connection (ITC) shall be within the range of 50-60m depending on the topography
g. The span of 33kV and 11kV network for township distribution network (TDN) shall be within the range of 45-50m depending on the topography
h. All angle 33kV and 11kV lines shall have stay wires installed at 30^0 angle
i. a double pole structure shall be used for every Tee Off connection and each pole structure shall be fitted with stay fittings

j. All angle points greater than 30^0 along inter town connections or township distribution networks shall be double pole structures and equipped with stay fittings.
k. All angle points equal or greater than 90^0 along inter town connections or township distribution networks shall be a minimum of 3 pole structure and equipped with stay fittings
l. Where channel iron cross arms are used, all shall be earthed at every pole as described in Chapter 11 of these regulations
m. All channel iron and angle iron to be used shall be of galvernized type
n. All cross arms (fiber,and channel/angle iron) shall be supported with a galvanized V-shape tie strap to firmly hold the cross arm in position on the electric poles;
o. There shall be adequate corridor for the construction of 33kV and 11kV overhead line without compromisisng the right of way as provided in clause 3.1 of these regulations.
p. The 33kV and 11kV Overhead lines shall be constructed to achieve pole alignment with respect to the topology of the route.
q. There shall be provision of line protection (autorecloser) at tee-off of all new 33kV lines to be interconnected with the primary feeder lines emanating from Transmission stations and shall be coordinated with transmission protection
r. Every tee-off of 33kV line from an injection substation shall be provided with overcurrent and earth fault protection
s. Where LT line crosses a road, it shall be through an underground PVC/SWA/PVC copper cable of appropriate cross-sectional area using the transbouring installation method.

5.4.3 Double circuit overhead 33kV and 11kV distribution lines:

All construction of overhead 33kV and 11kV lines shall conform to the provisions of section 5.4.2 of this regulation. In addition the following specifications shall apply;

a. Double circuit vertical overhead conductors shall be installed on 12.2m electric poles and the planting depth of 2.0m engraved on the pole as specified in NIS 586;2020
    i. The distance between phases of each circuit on each vertical axis shall be a minimum of 1.2m
    ii. The horizontal distance between the 2 circuits on either side shall be a minimum of 1.2m
    iii. Sectional poles shall be between 5-10 spans depending on the width and the terrain of the line route with a provision of 4 stay wires.
    iv. In the event a channel iron is used it shall be earthed at every pole as described in Chapter 11.
b. Double circuit horizontal overhead conductors shall be installed on 12.2m poles and the planting depth 2.0m engraved on the pole

i. The distance between phases on each of the circuit shall be 1.2m
ii. Each of the circuits (33kV or 11kV) shall be supported on fibre cross arms or galvanized channel iron which shall be earthed. In all cases a channel iron shall be supported with a galvanized V-shaped tie strap
iii. Fibre cross arms for 33kV and 11kV lines shall be of rectangular hollow section with an overall length of 2.7m and 1.8m respectively, with a cross section of 101.60mm x 76.20mm and overall thickness of 6.35mm
iv. Sectional poles shall be between 5-10 spans pending on the width and the terrain of the line route with a provision of 4 stay wires.

c. Dual circuit overhead lines shall be 33/0.4kV and 11/0.4kV and installed on a minimum of 10.36m electric poles
   i. The HT circuit arrangement shall be horizontal while the LT circuit arrangement shall be vertical
   ii. The stay wire shall be installed at a 30^0 angle to the pole
   iii. The vertical clearance between the 33kV & 0.4kV circuit shall be 1.3m
   iv. The vertical clearance between the 11kV & 0.4kV circuit shall be 1m
   v. Where the circuit of higher voltage is fully insulated, the clearances in iii & iv above, may be reduced by 50%

5.5 *Feeder Loading Capacity, Limit of Route Length and Load Threshold For Different Supply Voltages*

5.5.1 Feeder loading Capacity

The loading of distribution feeders shall comply with table 5.5.1 below:

5.5.2. the route length of distribution feeders in a distribution system shall comply with table 5.5.1

5.5.3 the load threshold for 33kV and 11kV feeders in a distribution system shall comply with table 5.5.1

Table 5.5.1 CONDUCTOR TYPE AND LOADING CAPACITY FOR 33kV & 11kV FEEDERS

		Span Length		Maximum Loading	Route Length
Type of construction	Conductor Type and Size	Min (m)	Max (m)	MW	KM
0.400kV	$70mm^2$, $100mm^2$ AAC	45	50	1	1
11kV	$100mm^2$ ACSR	45	50	5	18
11kV	$100mm^2$ AAC,	45	50	4.5	18
11kV	$150mm^2$ ACSR	45	50	6	18
11kV	$150mm^2$ AAC	45	50	5	18
33kV	$150mm^2$ ACSR	45	50	20	53
33kV	$200mm^2$ ACSR	45	50	25	53

33kV	$250mm^2$ ACSR	45	50	28	53

[1]

Support structures for ACSR conductors above $200mm^2$ shall be tubular poles or steel towers

[1] The span of 33kV and 11kV network for inter township connection (ITC) shall be within the range of 50-60m depending on the topography
The span of 33kV and 11kV network for township distribution network (TDN) shall be within the range of 45-50m depending on the topography

5.4 Service Drop Lines

5.4.1 Overhead Service Drop Lines

5.4.1.1 Service Lines Entering into Customer's Premises

Any service line of the licensee which is taken into the premises of a customer at a point below the level of the ground shall be taken into the premises in such manner as to prevent, as far as reasonably possible, any influx of gas at the point of entry

5.4.1.2 Identification of Conductors of Service Lines

The separate conductors of service lines shall be permanently marked by coloration, or in accordance with the provision of these Regulations for Electrical Installation, labelled as close as practicable to the supply terminal so as to indicate in a distinctive manner, the polarity of the conductors or the neutral and live phase conductors as the case may be.

5.4.2 Protection of Consumer's Installation against Excess Energy

For protection against excess energy, a suitable fusible cut-out or automatic circuit breaker of adequate rupturing capacity completely enclosed in a suitable locked or sealed receptacle of solid fire resisting construction shall be inserted by the licensee in every service line as close as practicable to the supply terminals and in a position which, in the opinion of the licensee, is suitable for the purpose.

Provided that no such fusible cut-out or automatic circuit breaker shall be inserted in any conductor, which is permanently connected with earth.

Provided also that where a supply of energy is given at high voltages, provision shall be made whereby the consumer is enabled to cut off all voltage from the supply terminals without risk or danger.

5.4.3 Licensee's Lines on Consumer's Premises

5.4.2.5 The licensee shall be responsible for all electric lines and apparatus placed by them on the premises of a consumer and either belonging to the licensee or under their control (whether forming the whole or part of the consumers installation or not) being installed and maintained in a safe condition and suitable for their respective purposes and being so fixed and protected as to prevent so far as is reasonably practicable, leakage to any adjacent metal.

5.4.2.6 The standard of construction and installation adopted by the licensee in complying with Clause 5.4.1.4a of this Regulation in so far as it relates to the whole or any part of a consumers installations shall not be lower than which the licensee would be prepared to accept under Section 7.

5.4.2.7 The obligation imposed by Clause 5.4.1.4a of this Regulation in regard to the maintenance of any electric lines and apparatus as aforesaid situated on the consumers side of the supply terminals and forming the whole or part of a consumer installation shall be subject to the terms of any agreement entered into between the licensee and the consumer with respect to the letting on terms or hire-purchase of the said whole or part of the consumers installation.

5.4.2.8 Nothing in this Regulation shall relieve the owner or occupier of any premises, being a consumer within the context of this Regulation from any obligation imposed on him/her by the provisions of clauses 5.2.1.4(a) to 5.2.1.4(c)

5.4.4 Inspection and testing of consumer's installation and appointment of installation Inspectors

5.4.4.1 Licensee shall appoint in writing, one or more competent persons to inspect consumers installations.

5.4.4.2 The licensee shall not permanently connect consumers installation supplied at low or medium voltage with their electric lines unless and until the said installation has been inspected and duly tested to determine compliance with the provisions of these Regulations.

5.4.4.3 The results of every test and inspection made in conformity with Clause 5.4.4.2 shall be recorded in writing and authenticated by the signature of the person appointed in conformity with Clause 5.4.4.1.

5.4.4.4 The provisions of this Regulation shall not apply to consumers installation coming within the provisions of the Minerals and Mining Act (Cap. 226), or the National Film and Video Censors Board Act (Cap N40), or where the installation to be supplied is made by another undertaking, instead the licensee shall ensure that the installation comply with the appropriate wiring Regulations if any or that the installation has been approved by an Inspector duly appointed to administer the appropriate wiring Regulations applicable to the particular installation, before commencing to give a supply.

5.4.5 General Conditions as to Supply to Consumers

5.4.5.1 The licensee shall not be compelled to commence or subject to the provisions, of these Regulations continue to give supply of energy to any consumer unless they are reasonably satisfied in respect of the consumer's installation.

5.4.5.2 That all conductors (including flexible conductors) and apparatus (including portable apparatus) are sufficient in size and capacity for the purposes for which the supply of energy is to be used and are constructed, installed and protected so as to prevent danger so far as is reasonably practicable; and that all single- pole switches are inserted in live conductors only.

5.4.5.3 That every distinct circuit is protected against excess energy by means of a suitable fusible cut-out or automatic circuit breaker of adequate rupturing capacity suitably located and of such construction as to prevent danger from overheating, arcing or the scattering of hot metal when it comes into operation and such as permit the renewal of the fusible metal without danger

5.4.5.4 That every electric motor is controlled by an efficient switch or switches for starting and stopping and that the said switch or switches is or are so placed as to be readily accessible to and easily operated by the person in charge of the motor.

5.4.5.5 Provided that installation shall be deemed to fulfil the requirements of this Regulation if it complies with the provisions of the NESIS Regulations or where applicable Regulations governing electrical installations made under the provisions of-

(a) the National Film and Video Censors Board Act [Cap. N40]); or
(b) the Minerals and Mining Act [Cap. 226];
(c) any other Act.

5.4.6 Supply at Low Voltage From More Than One Pair Of Conductors System At Medium Voltage

5.4.6.1 The licensee shall not commence a supply of energy at low voltage to any consumer from more than one pair of conductors of a three-wire or multi-phase system at medium voltage unless-

5.4.6.1.1 The total rating in kilowatts of the apparatus (including electric lamps) connected or intended to be connected to the consumer's wiring exceeds 10 kilowatts; and

5.4.6.1.2 The giving of the supply at low voltage from more than one pair of conductors of a system as aforesaid is necessary to avoid variation in excess of the limits allowed by latest version of the Nigeria Distribution Code in the voltage declared to that consumer or to any other consumer supplied from the same distributing main.

5.4.6.2 The licensee shall not in any case be compelled to commence, or subject to the provisions of Regulation 5.4.88 to continue to give a supply of energy at low voltage to any consumer from more than one pair of conductors of a system as aforesaid unless they are reasonably satisfied in respect of the consumer's installation-

5.4.6.2.1 That the supply terminal is arranged in separate parts in such a manner that so far as is reasonably practicable there shall be no danger of shock at medium voltage;

5.4.6.2.2 That the consumers wiring connected to the separate pairs of supply terminals is kept separate and distinct, or complies with the conditions applicable to a supply at medium voltage prescribed by Regulation 5.4.7.

5.4.6.2.3 That in the case of any room containing the different pairs of conductors all socket outlets are connected to one and the same pair of conductors.

5.4.6.3 Provided that any consumer's installation which complies with the provisions of the Regulations for electrical installations shall be deemed to fulfil the requirements of Regulations 5.4.6.2

5.4.7 Supply at Medium Voltage

5.4.7.1 The licensee shall not be compelled to commence or subject to the provisions of Regulation 5.4.9 to continue to give a supply of energy at medium voltage to any consumer unless they are reasonably satisfied in respect of the consumer's installation as to the following-

5.4.7.1.1 That all metalwork enclosing supporting or associated with the consumers installation, other than that designed to serve as a conductor is where necessary, to prevent danger connected with earth;

5.4.7.1.2 That the consumer's wiring is either completely enclosed in metal which is electrically continuous and adequately protected against mechanical damage or, alternatively, is so constructed, installed and protected as to prevent danger so far as is reasonably practicable.

5.4.7.1.3 That the supply of energy to each motor or separate NIS IEC of apparatus is controlled by an efficient cut-out switch placed in such a position as to be readily accessible to and easily operated by the person in charge of the said motor or apparatus and so connected in circuit that by its means all voltage can cut-off from the motor or apparatus itself and from any regulating switch, resistance or other device associated therewith.

5.4.7.2 Provided that an installation shall be deemed to fulfil the requirements of this Regulation if it complies with the provisions of the Regulations for electrical installation or where applicable Regulations governing electrical installation made under the provisions of-

(a) The National Film and Video Censors Board Act [Cap. N40]); or

(b) The Minerals and Mining Act [Cap. M12];

(c) Any other relevant Act.

5.4.8 Supply for Luminous Tube Sign On Outside Of Premises

5.4.8.1 The licensee shall not knowingly commence or subject to the provisions of these Regulations, continue to give a supply of energy to any consumer who proposes to transform or is transforming the energy to a higher voltage for the purposes of luminous tube sign or the like on the outside of any premises unless either they are satisfied with respect to consumers installation that-

(a) Efficient cut-off switch on the lower voltage side of the transforming apparatus are provided both inside and outside any premises on which the said sign is placed and in such position as to be readily accessible and easily operated without danger in any emergency and so connected in circuit that by their means all high voltage can be cut off from the sign itself and from any regulating switch resistance or other device associated therewith;

(b) No metal work designed to be electrically charged at high voltage will normally be exposed so that it can be touched.

(c) All conductor for use at high voltage (other than overhead lines and service wires) connecting the parts in a luminous tube sign or the like are completely enclosed in metal which is electrically continuous and where necessary to prevent danger adequately protected against mechanical damage, and that the said conductors are so arranged as to give a clear space of not less than 100mm between the outside of their metallic covering and the outside covering of any other electric line not forming part of the consumers installation or any part;

(d) All metal work enclosing supporting or associated with the consumers installation, other than that designed to serve as a conductor, is where necessary earthed to prevent danger;

(e) All winding at high voltage of apparatus within reach from any position in which a person may require to be efficiently protected so as to prevent danger;

(f) In respect of the transforming apparatus, suitable provision is made to guard against danger by reason of the circuit at lower voltage becoming accidentally charged above normal voltage by leakage from or contact with the circuit at higher voltage;

(g) Unless the conditions of supply are such that the whole of the conductors and apparatus may be made dead at the same time for the purpose of cleaning or for other work thereon, they are so arranged that they may be dead in sections, and that such sections are so electrically isolated from all adjacent metal which is live that work on any section made dead may be carried out by an authorized person without danger;

(h) Adequate means are provided for preventing any unauthorized person from coming into contact with any part of the consumer's installation which is designed to be electrically charged at high voltage and that an appropriate danger notice is displayed at points of access thereto; or

5.4.8.2 Where the consumer informs the licensee, in writing, that the installation has been done and will be maintained in compliance with the provisions of the NESIS Regulations the installation shall be deemed to fulfill the requirements of this Regulations.

5.4.8.3 Provided that where it can be shown that in the event of an accident involving death or injury to any person or persons, the customer had failed to install or maintain the installation in compliance with any written guarantee shall be liable to prosecution under the provisions of these Regulations.

5.4.9 Disconnection of Supply in Certain Circumstances

5.4.9.1. Where a supply of energy is being afforded to a consumer and the licensee after making such examination as the circumstances permit have reasonable ground for supposing that a leakage likely to cause fire hazard or endanger life exists at some parts of the installation or that the said installation or any part thereof fails to fulfill any requirements of Regulations 5.6.6 to 5.6.9 inclusive, the following provisions shall (subject as provided in paragraph (2) of this Section) have effect: -

i. In any case where the licensee is prima facie satisfied that immediate action is justified as a work of emergency in the interest of the public safety or in order to avoid undue interference with the efficient supply of energy to other customer they may as a work of emergency forthwith discontinue the supply of energy to the customers installation and shall give immediate notice in writing of the discontinuance to the customer, specifying the matter complained of.

ii. In any other case, the licensee may by notice in writing require the customer within reasonable time after the service of the notice to permit an inspecting engineer to inspect and test the said installation at any time between the hours of 8: 00a.m and 4:00p.m. If the customer does not give all due facilities for inspection and testing, or if as the result of any such inspection and testing, the Installation inspector makes a report confirming the existence of a leakage from the customers installation or report that the said installation or any part thereof fails to fulfil the requirements 5.6.6 to 5.6.9 inclusive, the licensee may forthwith by notice in writing, specify the matter complained of, and if the customer fails to show to the reasonable satisfaction of the licensee within such reasonable period as may be specified in the notice that the said matter has been remedied, the licensee may on the expiration of the said period, but subject as hereinafter provided, discontinue the supply of energy to the customers installation, giving immediate notice in writing of such discontinuance to the customers.

iii. Any dispute which may arise between a consumer and the licensee in regard to any matter complained of or as to the period specified for remedying the same in any notice as aforesaid shall be settled in a manner provided for in the latest version of the Nigeria Metering Code.

iv. In exercise of the powers conferred by paragraph (1) *(b)* of this section, the licensee shall not discontinue the supply of energy pending the settlement of any differences referred to in paragraph (1) *(c)* of this section, and shall in no case discontinue the supply of energy to the whole of the customer's installation, where it is practicable to disconnect that portion in respect of which any matter is complained of.

v. Provided that nothing in this Section shall prevent the licensee from exercising the powers conferred by paragraph (1) *(d)* of this Section in the event of the development of a condition of emergency as therein provided;

vi. Where in pursuance of this Regulation the licensee has discontinued the supply of energy to the customers installation or any part thereof, the licensee shall not recommence the supply of energy until they are reasonably satisfied in respect of the customer's installation that all requirements of Regulations 5.4.5 to 5.4.77 inclusive have been fulfilled or until it has been determined or decided in the manner provided for in the latest version of the Nigerian Metering Code that licensee is not entitled under Regulation 5.4.55 to 5.4.55 inclusive to decline to recommence the supply and thereupon the supply of the energy shall be recommenced by the licensee.

5.4.9.2. The foregoing provisions of this Regulation shall extend so far as applicable and with the necessary adaptations to any electric lines and apparatus situated on the consumers side of the supply terminals and belonging to the licensee or under their control within the meaning of Regulation 5.4.44 and where the supply of energy has been discontinued in pursuance of the said provisions , the licensee shall subject to the respect to the letting on terms of hire or hire- purchase of any such electric lines and apparatus, forthwith remedy the defect in the said electric lines and apparatus and recommence the supply of energy.

5.4.10 Notices by Licensee to Consumers on Connection Declination or Supply Disconnection

5.4.10.1. In any case where the licensee in pursuance of this part of these Regulations decline to connect a consumer's installation or any part thereof with their electrical lines or to commence or continue to give a supply of energy thereto or decline to recommence the supply of energy after the same has been discontinued, they shall serve on the consumer a notice in writing stating their reasons for so declining.

5.4.10.2. Any dispute which may arise between a customer and the licensee either with reference to any notice under paragraph 5.4.10.1 or with reference to any customer's installation to which the provisions of Regulations 5.4.4.1 and 5.4.5.1 apply, shall be determined by an Inspector nominated by the Commission on the application of the customer or his authorized agent or of the licensee, as the case may be. The Commission shall prescribe the fee to be paid to such Inspector and the Inspector shall determine which of the parties shall bear the costs of (including the prescribed fee) or any portion of such costs.

5.4.10.3. Provided that in the case of any customer installation (or any part thereof) which was connected with the electrical lines of the licensee and supplied with energy prior to the prescribed date, it shall not be competent for an Inspector nominated under this Regulation to determine that the licensee was or are entitled under Regulations 5.4.6 to 5.4.9 inclusive to refuse a supply of energy thereof if the Inspector is satisfied that: -

i. the said installation has continued to function satisfactorily up to the material time;

ii. the installation is to be or is being continued in use only within the limits of the maximum power for which it was originally intended; and

iii. there are no grounds for supposing that the installation will fail to continue to function satisfactorily for a further reasonable period without risk or danger

5.4.10.4. If the licensee or the customer or his authorized agent is dissatisfied with the determination of the Inspector, she/he may appeal to the Commission and thereupon the Commission shall enquire into and decide upon the matter of the appeal and the Commission's decision shall be binding on all parties.

5.4.10.5. This Regulation and Regulation 5.4.9 shall be endorsed on every notice given by the licensee to a customer under the provisions of either of the said Regulations, or alternatively a copy of each of the said Regulation shall accompany the notice.

5.4.11 Exterior Wall Lines at Consumer Facilities

Service drop lines shall be extended to customer's premises through either of the following:

5.4.11.1. Direct connection or termination at the customer premises using a complete D-Iron bracket or wall NIS IEC insulator firmly anchored with hardcore concrete mix. Minimum service cable cross sectional area shall be $16mm^2$ Aluminium PVC insulated cable for single-phase supply.

5.4.11.2. Underground connections from the nearest service pole to the customer meter position. Customers with load profile up to 10kW shall be serviced on three phase 4-wire with cable of minimum cross-sectional area of $10mm^2$ x 4-core or $16mm^2$ aluminium PVC insulated cable.

5.4.12 Temporary Service Drop Lines

Request for temporary service drop lines shall abide by the requirements outlined below::

5.4.12.1. Prospective customer shall apply to the licensee for temporary electricity supply using prescribed format.

5.4.12.2. The licensee or his representative shall inspect or examine the possibility of providing the electrical power as requested.

5.4.12.3. The licensee shall advice the customer of requirements for provision of temporary electric supply if found that electric power supply can be extended.

5.4.12.4. Installation shall be examined and certificate submitted by licensed electrical wiring contractor indicating all electrical works have been done in accordance with extant Regulations.

5.4.12.5. Electrical service connections including metering shall be arranged by the licensee if all the requirements have been met.

5.4.12.6. If the electrical load requirements cannot be met, the customer shall be informed in writing. On receipt of the decline of connection, the contractor/customer shall make alternative arrangements for supply of electrical power to his installation.

5.4.12.7. If the electrical load requirement can be met, the licensee shall approve request as per application.

5.4.12.8. The customer shall draw from the network the energy required as per request up to a total load indicated in the application.

5.4.12.9. The electrical power to the customer shall be in the form of single phase or three-phase alternating current at a nominal frequency of 50Hz.

5.4.12.10. The customer shall pay the cost towards electrical installation and security deposit as demanded by the licensee.

5.4.12.11. The customer shall pay for the cost of electrical energy as agreed upon by both parties.

5.4.12.12. If customer fails to pay for the energy consumed within the time as stipulated by the licensee, it shall be lawful for the distribution company to cut off the supply of power after giving 15 day’s notice.

5.4.12.13. The quantity of electrical energy supplied by the licensee to the customer shall be ascertained by means of a meter or meters to be provided by the licensee.

5.4.12.14. The said meter or meters, shall at all reasonable time be open to the licensee or his authorized representatives. The meters shall be properly sealed on behalf of both parties and shall not be interfered with by either party except in the presence of the other party or his representatives duly authorized on that behalf.

5.4.12.15. The customer shall not make any alteration on the machinery or equipment either by way of addition or substitutions or transfer which is liable to increase the obligation of the licensee to supply electrical energy in excess of the agreed demand and or which may affect the supply system of the licensee to its detriment.

5.4.12.16. In any event, the customer shall notify the licensee of the intended alterations, additions, substitutions or transfer and obtain the prior approval of the licensee in writing before execution of any such action.

5.4.12.17. The power factor of the plant and apparatus owned and operated by the customer at individual points of supply shall not ordinarily be less than 0.90. If it tends to drop below 0.90, it shall be improved by the installation of static capacitors, failing which; the supply shall be disconnected with a 10 working days notice.

5.4.12.18. Electrical supply under this agreement is guaranteed to the customer subject to availability of adequate power from the national grid and in case of non-availability of power supply from the national grid, no alternate source of power shall be made available to the customer.

5.4.12.19. The licensee and customer shall agree that it shall be competent for either party to terminate this agreement by issue of 10 working days' notice sent by registered post.

5.4.12.20. Safe operation and maintenance of internal wiring, electrical fittings and installations will be the responsibility of the customer in such conditions as to be free from danger as per provisions stipulated in this Regulation

5.4.12.21. Power supply shall be used only for the purpose requested for and not for any other purpose. If the supply is used for any other purpose, or extended to a third party, the licensee will disconnect the supply after due notice except in circumstances covered by Section 6 of Connection and Disconnection Procedure Regulations of NERC.

5.4.12.22. The licensee is responsible for any accident, damage or injury that may result from or through the presence of electrical connection to the extent specified in BS 7671-2008 for places under this category and to the extent specified by the Nigerian Electricity Health and Safety Code as amended.

5.5 Underground Distribution

5.5.1 General Requirements

Underground distribution lines shall consist of networks constructed with cables and associated equipment according to prescribed standards. All cables, whether for A.C. or D.C. and for all voltages, shall be insulated as required and manufactured in accordance with appropriate Nigerian Industrial Standard Specifications. Where steel armouring is employed, it shall be effectively earthed and bonded at all joint boxes so as to be electrically continuous.

Standard cable sizes and characteristics for underground distribution lines are as contained in NIS IEC 60502.

Cables shall be of hard drawn stranded copper. Bare aluminium cables shall not be used for underground distribution network.

5.5.2 Properties of Underground Distribution Cables

5.5.3.5 Classification of Cables

Cables shall be classified according to the operating voltages as follows:

a. Low Voltage Cables Rated up to 2,000 volts
b. Medium Voltage Cables Rated 2,001 through 46,000 volts
c. High Voltage Cables Rated 69,000 volts to 500,000 volts
d. Extra High Voltage Cables rated above 500,000 volts

5.5.3.6 Voltage Rating

Distribution cables to be used in underground distribution network shall be rated based on phase-to-phase voltage values.

5.5.3.7 Cable Insulation Resistance

Underground cables shall possess adequate insulation resistance level to permit minimum leakage current within the operating temperature that will guarantee safety in operation. The impulse and dielectric strength of cables on medium voltage lines shall be capable of withstanding 75kV and 170kV on 11kV and 33kV voltage levels respectively.

5.5.3.8 Materials

Cables for use on medium and low voltage circuits shall be copper conductor impregnated paper insulated belted 4-core, lead sheathed cables complying with NIS NIS IEC 60055-2, 4-core cables shall be steel tape or stranded armoured, PVC insulated cables complying with NIS NIS IEC 60502 shall also be used. Cross-linked polyethylene (XLPE) cables shall also be accepted in medium voltage underground distribution lines.

The sizes of cables shall be as shown in table 5.5.2.4

Table 5.5.2.4

Number of	Nominal Conductor Size and Material
4	35mm^2 copper for customer's services only
4	70mm^2 copper for mains and uprisers
4	150mm^2 copper for mains and uprisers
Single	185mm^2 copper from Transformer to Feeder Pillar (LV Cable)
"	300mm^2 copper Transformer to Feeder Pillar (LV Cable)
"	500mm^2 copper Transformer to Feeder Pillar (LV cable)
3	120 – 185mm^2 (Medium voltage)
1	240 – 500mm^2 (Medium voltage)

5.5.3 Jointing Requirements for Underground Distribution Cables

5.5.3.1 General Requirements for Cable Joints and Terminations

The following general requirements shall be satisfied when making joints and terminations:

a. All heat shrink components shall be kept free of contamination during jointing.
b. Cable ends being worked on shall be kept free of any damage or contamination during the jointing process.
c. Cable cores shall not be bent tighter than the manufacturers' specified minimum internal bending radii either during the jointing process or after they have been set in position.
d. All components used for jointing and terminations (including cable components), which will come into contact with either masking tape or adhesive sealants, shall be thoroughly cleaned and degreased prior to the application of these sealing agents. Cleaning shall only be done using lint-free cloth.
e. Heat shrink tubings shall be positioned correctly, and properly and evenly shrunk, free of voids and shall not be damaged due to overheating. Heat shrink components with adhesive sealant coatings shall provide effective sealing against moisture ingress when installed.
f. The specified overlapping distances between various heat shrink tubings and cable components shall always be adhered to.
g. Completed joints and terminations shall be allowed to either cool down or set before they are subjected to any further mechanical load.
h. The three active cable cores shall be coloured red, yellow and blue. The neutral core shall be coloured black.
i. The completed joint if directly buried, shall be surrounded in soft bedding material up to a depth of 100 mm above the joint.

5.5.3.2 *Cable Terminations and Joints*

Three-core cables:

a. The minimum internal bending radius of the cable, electrical clearances in cable end boxes and the practical aspects of cable laying shall dictate termination of 3-core cables.
b. Trifurcation, three core terminations and three-to-one joint methods of termination shall apply to appropriate cable sizes to meet the requirements of internal bending radius and safe clearances at the end boxes.
c. The lugs shall be of the compression type and shall have sealed palms and barrels (except for the cable entry end). Compression lugs shall be installed in strict compliance with the manufacturer's recommendations of crimps. Lugs shall be long barrel type and suitably sealed for outdoor use.

5.5.4 Installation of Underground Distribution Cables

Cables shall be laid in well dug out twin wall corrugated ducts and identified with route markers made visible and securely placed as not to cause obstruction in any form.

5.5.4.1 *Excavation of Trenches*

a. The cables shall be laid at a depth of not less than 1 metre below surface level and in cases where two or more power cables are laid in the same trench, a minimum distance of 300mm shall be maintained between the cables.
b. To prevent the cables being damaged by stones the cables shall be laid in a bed of sifted soil or sand and to prevent mechanical damage the cables shall be protected by inter-locked tiles sufficiently wide to give a minimum of 50 mm on each side of the cable and laid approximately 150 mm above the cables.
c. The cable route shall be indicated at surface level with cable markers at suitable intervals, particularly at positions where the cable changes direction stating the voltage levels.

5.5.4.2 *Depth of Cable Laying*

The depth of laying and trench dimensions shall be as specified in table 5.5.4.2. Any variation from the specified depth shall be approved by NERC. When cables are laid under or along a railway line and within a zone of 1.83m measured from the nearest rail, a depth of 1.25m to the top of the cables shall be maintained unless otherwise specified.

Table 2a

Voltage	LV and MV			Combined MV/11KV		
	In Footpaths	Across Carriageways	Along Carriageways	In	Across Carriageways	Along Carriageways
Depth of Trench	460mm	610mm	910mm	610mm	760mm	910mm
Width of Trench	300mm	300mm	460mm	380mm	300mm	460mm

5.5.4.3 Method of Cable Laying

The arrangements of the cable or cables, and all methods of laying over the whole route shall be as specified. The methods of laying shall be as follows:

a. Laid direct in the ground
b. Drawn into pipes and ducts

5.5.5 Route Identification of Underground Distribution Cables

5.5.5.1 Cable routes

a. Underground cable routes shall be planned bearing in mind the type of use, or foreseeable use, to which the land is or may be put in use.
b. Cable routes shall be along the footpaths and across roads.
c. Routes shall not be planned along carriageway unless other alternative routes are not reasonably practicable.
d. Where a cable route crossing a private land is unavoidable then a permanent easement shall be obtained.

5.5.5.2 Routes to Avoid special Areas

Cable route along areas of land with natural features and having legal protection due to their environmental character or sensitivity shall be avoided. Such designations include reserves, special areas of conservation and scheduled ancient monuments.

5.5.6 Cable Arrangements

5.5.6.1 Laid Direct in Footpaths

When medium voltage or low voltage cables are laid in footpaths, they shall be laid direct in the trenches. The trenches shall be of width 300 mm and depth 600 mm for both one circuit and two circuits. Trenches designed to accommodate two circuits and two spares shall be of width 380mm and depth 760mm.

5.5.6.2 Laid Along Carriageways

Cable laid along carriageways, medium and low voltage cables shall be laid direct in trenches of dimensions 460mm wide and 910mm deep.

5.5.6.3 Combined Cable Laying Arrangements for Different Voltage Levels

Where it is found necessary to lay medium voltage cables in the same trench, the construction shall be carried out as detailed below:

5.5.6.3.1 Laid-In Footpaths

If one medium voltage and one high voltage circuit are to be accommodated, the high voltage cable shall be laid 230 mm deeper than the medium voltage cable, topped with 80 mm of backfilled and covered with cable slabs. The maximum depth of the trench shall be 600 mm and its width shall be 380 mm. The cable cover shall overlap the high voltage and any associated pilot cable by at least 40 mm on either side. If one medium voltage and two high voltage cables are to be laid in the same trench, the two high voltage cables shall be laid at the bottom of the trench and the medium voltage cable laid midway between them at a height of 230 mm above them on a level with the cable protective covers. The width of the trench shall be 530 mm and its overall depth 600 mm.

5.5.6.3.2 Laid-In Ducts

When medium and high voltage cables are to be laid in ducts in the same trench, the arrangement shall be as described below and one of the spare ducts shall be used for the medium voltage cable.

Table 3.2

Number of Circuit(s)	**Depth**	**Width**
One	600 mm	300 mm
One Plus spare or two	600 mm	600 mm
Two plus two spares	760 mm	600 mm

5.5.6.3.3 Laid Along Carriageways

Along carriageways, both medium and high voltage cables shall be laid to a depth of 910 mm. The high voltage cable shall be covered with its protective cover. The trench width shall be 460 mm.

5.5.6.4 Ducts

Cable ducts shall be non-metallic and comply with NIS IEC 61084:1-2. The size of ducts required for different type of cables is shown in Table 5.5.6.4.

Table 4

Description	Nominal Duct Sizes (mm)
All HV Feeder Cables	150
HV Transformer Cables >35 mm^2	150
HV Transformer Cable <35 mm^2	100
All LV Main Cables	100
All Streetlight Cables	50

5.5.7 Underground Distribution Cables Adjacent to and or Crossing Other Objects

5.5.7.1 Railway Crossings by Underground Cables

All proposals in respect of railway crossings shall be submitted by the Licensee in writing within 30 days and not later than 90 days to the relevant authority specifying the intended use of the works. All cables shall be drawn into non-metallic pipes, such as earth wire, fibre, etc which shall be laid at a minimum depth of 1.25 m below rail level measured to the top of the highest pipe, and shall be surrounded by not less than 250 mm of concrete. The pipes shall extend at least 300 mm beyond the sleeper ends and be bushed to prevent chafing and ingress of stones.

5.5.7.2 Road crossings by Underground Cables

Where cables have to cross under roads, they shall be drawn into non-metallic pipes such as fibre. These pipes shall be laid at a minimum depth of 1.0 m below surface of the road measured to the top of the highest pipe and cable tiles shall be laid in a bed of sifted soil or sand and to prevent mechanical damage. Interlocked tiles sufficiently wide to give a minimum of 50.0 mm on each side of the cable and lead approximately 150 mm above the cable shall protect the cables. The end of the pipes shall be packed with a suitable bushing to avoid chafing and the ingress of stones.

5.5.7.3 Proximity to Water and Petrol Pipes

Cables shall not be laid at a distance of less than 1.0 m from pipes carrying water or petrol.

5.6 Special Distribution Lines

The following Regulations shall apply for special distribution lines:

5.6.1 Over Water and Under Water Distribution Cables

5.6.1.1 Electric Lines Crossing Waterways

a. The height of an electric line under, the most adverse conditions, above the highest recorded water level, over harbours, rivers and waterways, shall not be less than that required by the appropriate authorities for physical safety clearance, plus a minimum electrical safety clearance of 3.0 m or 1.0 m per 78 kV or phase to neutral voltage of the electric line, whichever is greater.

b. The Licensee shall, at least within thirty (30) days and not more than ninety (90) days prior to the placing of such work, serve written notice on the appropriate authorities specifying the intended use of the works, the voltage of operation and such other information that the authorities may require.

c. Every notice served in conformity with Clause 5.6.1.1(b) shall be accompanied by a plan of suitable scale indicating the site of the crossing, the location of all supports, stays, struts, switches, transformers and other apparatus intended to be used.

d. The authorities may within 21 days of the receipt notify the licensee of its decision which may be:

i. approved;

ii. approved subject to any condition;

iii. prohibit and serve a counter notice on the licensee:

(a) objecting to the siting of the works specifying the reason in the counter notice;

(b) requiring protective features to be fitted, within a stipulated period e.g. 3 (three) months and such features to be specified in the counter notice.

(c) if already implemented, a declaration that the "electric lines crossing waterways is prohibited".

5.6.2 Distribution Lines over Bridges and Other Structures

Risk Assessment shall be carried out taking into account the frequency and type of activities at risk. The crossing of distribution lines over bridges shall preferably be at right angles but not less than 30^o to minimize the length of exposure of the distribution line to vehicles. Towers shall be used where this can mitigate the risk of crossing.

5.6.3 Distribution Lines with Aerial-Bundled Cables

Aerial Bundled Cables (ABC) shall be accepted for overhead power distribution lines. It shall be XLPE Insulated Aluminium Conductor laid on high tensile stranded galvanized steel with a bare messenger wire.

The operating temperature range shall fall within 5ºC to 90ºC and permissible sag of 1.5% of the span at the lowest ambient temperature. Mid span joint is not permissible in high tension line construction and outdoor type termination is acceptable while ensuring continuity of the semi-conductor screen at all joints where applicable.

5.6.3.1 Medium Voltage (MV) Aerial Bundled Cables

a. General Requirements for MV Aerial Bundled Cables (ABC)

High Voltage Aerial Bundled Cables shall be XLPE insulated with a maximum operating voltage of 12 kV designed for use in overhead distribution lines. The cable shall comprise three single-core cables twisted around a bare Aluminium alloy messenger wire, which shall carry the weight of the cable.

b. *Cable Conductors*

The cable conductors shall be of round, stranded and compacted Aluminium of nominal cross-sectional area of 35 mm^2 / 70 mm^2 / 95 mm^2 /120 mm^2.

c. *Insulation*

The insulation shall be of extruded cross-linked polyethylene (XLPE), Dry Gas cured of nominal insulation thickness of 3.6 mm.

d. *Messenger (Neutral Conductor)*

The bare messenger wire shall be of 70 mm^2 / 80 mm^2/ 100 mm^2 (nominal area) Aluminium alloy.

There shall be no joints in any wire of the stranded messenger conductor except those made in the base rod or wires before final drawing.

5.6.3.2 Low Voltage Aerial Bundled Cables

a. *General Requirements for LV Aerial Bundled Cables (ABC)*

Low voltage Aerial Bundled Cables (ABC) shall be polyethylene insulated Aluminium cables twisted over a central bare Aluminium alloy messenger wire for use on L.T. overhead lines. The rated voltage of the cables shall be 1000 Volts.

b. *Phase Conductors of Aerial Bundled Cables*

The phase conductors and street lighting conductors where applicable shall be made of Aluminium and shall be stranded in construction and shall be insulated with black weather resistant polyethylene suitable for 1000 Volts insulation.

i. The insulated conductors shall generally conform to the NISNIS 359.

ii. The phase conductors shall be provided with suitable means for quick identification.

iii. The tensile strength of the Aluminium wires used in the conductors shall not be less than 90 N/ mm^2.

iv. The standard sizes shall include 16 mm^2, 25 mm^2, 35 mm^2, 50 mm^2, 70 mm^2, 95 mm^2 and 120 mm^2.

c. *Messenger (Neutral Conductor)*

i. The bare messenger wire shall be made of Aluminium alloy composed of 7 strands and shall be suitably compacted to have smooth round surface to avoid damage to the polyethylene insulation of the phase conductors twisted around the messenger.

ii. There shall be no joints in any wire of the stranded messenger conductor except those made in the base rod of wires before final drawing. The standard sizes shall include 25 mm2, 35 mm2, 50 mm2 and 70 mm2.

Chapter 6: Distribution Substations

6.1 Civil Works

The Design of the civil works for Distribution Substations shall be as specified in Clause 4.1 of these Regulations.

6.2 Basic Distribution Substation Components

6.2.1 Distribution Transformers

A Distribution Transformer does the final voltage transformation in electric power distribution system stepping down medium voltages to low voltages. Distribution Transformer can either be of single-phase type or three-phase type. Three phase Distribution Transformer shall have a vector group of Dyn11. Transformers used in Distribution Substation shall conform to the specifications of NIS IEC 60076 (All Parts).

6.2.1.1 *Transformer Protection Devices:*

The protection devices for distribution transformers shall allow for the normal range of operating current due to energisation, transient current, lightning and heavy temporary loading. Protection devices shall also be adequate to protect the transformer during extended period of heavy overload thereby protecting the system from transformer failure.

a. Transformer Primary Protective Devices
Fuses for the protection of distribution transformers shall be installed in accordance with manufacturer's specifications based on the transformer nominal capacity

b. Transformer Secondary Protective Devices
HRC fuses fitted in the feeder pillars shall be used for the protection of the transformer secondary circuit as specified in Clause 6.3. 1(a) of this regulation

6.2.2 Connection Cables

The following Regulations shall apply for the safe operation of transformer cables:

6.2.2.1 Medium Voltage Cables

a. Medium Voltage Cables are cables that are capable of operating at nominal voltage range of 1,000V to 33,000V.
b. The insulation withstand voltage of high tension cables shall not be less than twice the nominal voltage rating of the cable as specified in NIS IEC 60502-2.

6.2.2.2 Low Voltage Cables

a. Low Voltage Cables are cables that are capable of operating at nominal voltage of less than 1,000V.
b. All Low Voltage cables shall be in compliance with Clause 6.2.2.2(a) of this regulation. The low voltage cables for 400/230 V level are to consist, according to requirement of single, two and four-core low voltage power cables, unless otherwise specified in NIS IEC 60228.

c. The standard phase colour shall be Red (L1 or R), Yellow (L2 or Y), Blue (L3 or B) (RYB), Black for neutral (n) and Yellow-Green for earthing (E or G) conductor unless otherwise specified in NIS IEC 60228.
d. The insulation withstand voltage of low tension cables shall not be less than twice the nominal voltage rating of the cable as specified in NIS IEC 60502-1.

6.3 Low Voltage (LV) Distribution Panels (Feeder Pillar)

6.3.1 Structural and Mechanical Specifications

a. Distribution Feeder Pillars can be designed / manufactured as a four- way, six way or eight -way for power distribution application.
b. Rear mounted phase bus bar, single/double door construction, weather proof coating (in line with NIS IEC 62208), rubber seal gasket, must have neutral and earth bus bars.
c. Feeder Pillars shall be installed on a plinth of not less than 600 mm from the ground furnished with tamper proof lock and appropriate cable clamp.
d. Feeder Pillars shall be fitted with incomer and outgoing HRC fuses of appropriate rating

6.3.2 Electrical Insulations

The electrical insulation of Low Voltage Feeder Pillar shall be capable of withstanding a voltage not less than two times its nominal voltage.

6.3.3 Metering

Low Voltage Distribution Feeder Pillars shall be metered for the purpose of measuring the parameters of the distribution network at each substation. The following instruments shall be installed for the measuring of LV feeder pillar parameters;

a. *Ammeter:*
At least one ammeter shall be installed on a feeder pillar incomer bus bar.

b. *Voltmeter:*
Voltmeter shall be installed on a feeder pillar to show line-to-line and line-to-neutral voltages.

c. *Energy Meter:*
Energy Meter for low voltage distribution feeder pillar panels shall be installed in accordance with the requirements of the Nigerian Nigeria Metering Code as amended.

6.4 Compact Distribution Substation

Compact Distribution Substation shall be of indoor, outdoor or underground substation type with compartment for medium voltage switchgear, transformer and low voltage distribution panel complete with necessary connection accessories in accordance with the requirements of NIS IEC 62271-202.

6.5 The compartment should be spacious for ease of operation and maintenance in line with NIS IEC 62271-202:2022 standards. Pole Mounted Distribution Substation

6.5.1 The requirements for distribution transformer specified in Clause **6.2.1** of this regulation shall apply.

6.5.2 Pole mounted transformers for overhead Distribution Substation shall be installed at a minimum height of 3.0 m from the base of the pole. All steel materials to be used for installation shall be of galvanised type in line with NIS IEC 60776 standard for improved public safety.

6.5.3 The nominal operating voltage for pole mounted transformer substation shall lie between the medium voltage range and low voltage.

6.5.4 The maximum capacity allowed for pole mounted installation shall be 100kVA

Chapter 7: User's Sites Electrical Installations

7.1 General Provisions

This Regulation applies to all user's sites installations connected to any electrical power supply under the authority of a license granted under the Act (whether granted before or after the coming into force of this Regulation), and to all user's sites irrespective of their source of supply shall be in the following configurations and voltages:

a. Single phase 2 wire supply at 230 Volts
b. Three Phase 4-wire supply at 400 Volts
c. Single Wire Earth Return (SWER) supply at 400 and 230 Volts

7.2 Electrical Services Design Standard Requirement

NIS IEC

Every user's site electrical installation shall be designed, and approved by COREN Registered Electrical Engineer. All such electrical designs shall, however, meet the applicable standards stated herein, and where no provisions have been made in this regulation, relevant NIS standards shall apply.

For the design of the electrical installation, the following factors shall be taken into account to provide

a. the protection of persons, equipment and property in accordance with Clause 131 of NIS IEC 60364-2005
b. the proper functioning of the electrical installation for the intended use.

7.2.1. Characteristics of Power Supply in the NESI

When designing electrical installations, it is necessary to know the characteristics of the supply. Relevant information from the network operator to design a safe installation. The characteristics of the power supply should be included in the documentation to show conformity with NIS IEC 60364 series.

7.2.1.1 Values and tolerances:
Values of voltage and frequency at the user site shall comply with NIS IEC 60038 series standard.

7.2.1.2 Nature of demand

The number and type of circuits required for lighting, heating, power, control, signaling, information and communication technology, etc. shall be determined by:

a. location of points of power demand;
b. loads to be expected on the various circuits;

c. daily and yearly variation of demand;
d. special conditions such as harmonics;
e. requirements for control, signaling, information and communication technology, etc.; and
f. anticipated future demand if specified.

7.2.1.3 Environmental conditions

The design of the electrical installation shall take into account the environmental conditions to which it will be subjected in accordance with the provision of NIS IEC 60364-5-51 and NIS IEC 60721.

7.2.1.4 Cross-sectional area of conductors

The cross -sectional area of conductors shall be determined for both normal operating conditions and for fault conditions according to

a) their admissible maximum temperature as prescribe in table 7.2.3.4.1b
b) the admissible voltage drop as prescribe in table 7.2.3.4.1a[2]
c) the electromechanical stresses likely to occur due to earth fault and short-circuit currents;
d) other mechanical stresses to which the conductors can be subjected;
e) the maximum impedance with respect to the functioning of the protection against fault currents; and
f) the method of installation.

NOTE The items listed above concern primarily the safety of electrical installations. Cross-sectional areas greater than those required for safety may be desirable for economic operation.

7.2.1.5 Type of wiring and methods of installation

For the choice of the type of wiring and the methods of installation the following shall be taken into account:

a. the nature of the locations;
b. the nature of the walls or other parts of the building supporting the wiring;

[2] In many instances this may well be the most onerous condition to affect cable sizes. These Regulations require that the voltage at the terminals of fixed equipment should be greater than the lower limit permitted by the British Standard for that equipment, or in the absence of a British standards, that the safe functioning of the equipment should not be impaired.

c. accessibility of wiring to persons and livestock;
d. voltage;
e. the electromagnetic stresses likely to occur due to earth fault and short-circuit currents;
f. electromagnetic interference; and
g. other stresses to which the wiring can be subjected during the erection of the electrical installation or in service.

7.2.1.6 Protective equipment

The characteristics of protective equipment shall be determined with respect to their function which may be, for example, protection against the effects of:

a. overcurrent (overload, short-circuit);
b. earth fault current;
c. overvoltage; and
d. undervoltage and no voltage.

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

7.2.1.7 Emergency control

Where, in case of danger, there is the necessity for the immediate interruption of supply, an interrupting device shall be installed in such a way that the faulty circuit can easily be detected effectively and rapidly isolated.

7.2.1.8 Disconnecting devices

Disconnecting devices shall be provided so as to permit switching and/or isolation of the electrical installation, circuits or individual items of apparatus as required for operation, inspection, fault detection, testing, maintenance and repair.

7.2.1.9 Prevention of mutual detrimental influence

The electrical installation shall be arranged in such a way that no mutual detrimental influence will occur between electrical installations and non-electrical installations.

7.2.1.10 Accessibility of electrical equipment

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

a. sufficient space for the initial installation and later replacement of individual items of electrical equipment; and

b. accessibility for operation, inspection and fault detection, testing, maintenance and repair.

7.2.1.11 Documentation for the electrical installation

Every electrical installation shall be provided with appropriate documentation

a. Design/as Built drawings;
b. Labeling of final sub-circuit at the distribution board; and
c. General Schematic diagram or layout of power supply at the premises.

7.3 Indoor Installation

The indoor installation for any user's site shall take the following into consideration:

i. Maximum safety to life and property;
ii. Efficient utilisation of electrical energy; and;
iii. Environmental protection.

The Standards set out hereunder are aimed at achieving these considerations and shall require accurate information of the user's site. The approving authority shall ensure strict compliance with the NIS Standards.

7.3.1 Restriction of Indoor Lines Voltage

The line-to-earth voltage of an electric facility in a User Site shall be as stated in Part II, *Section 4.3.1 of the Distribution Code as amended.* Or less according to the safety measures mentioned in the following clauses:

7.3.1.1 In the case of TT earthing type (See Figure 7.2.2.1), Earthing work Class D of Table 3.9.2b shall be given to any single-phase low-voltage equipment irrespective of the user's site.

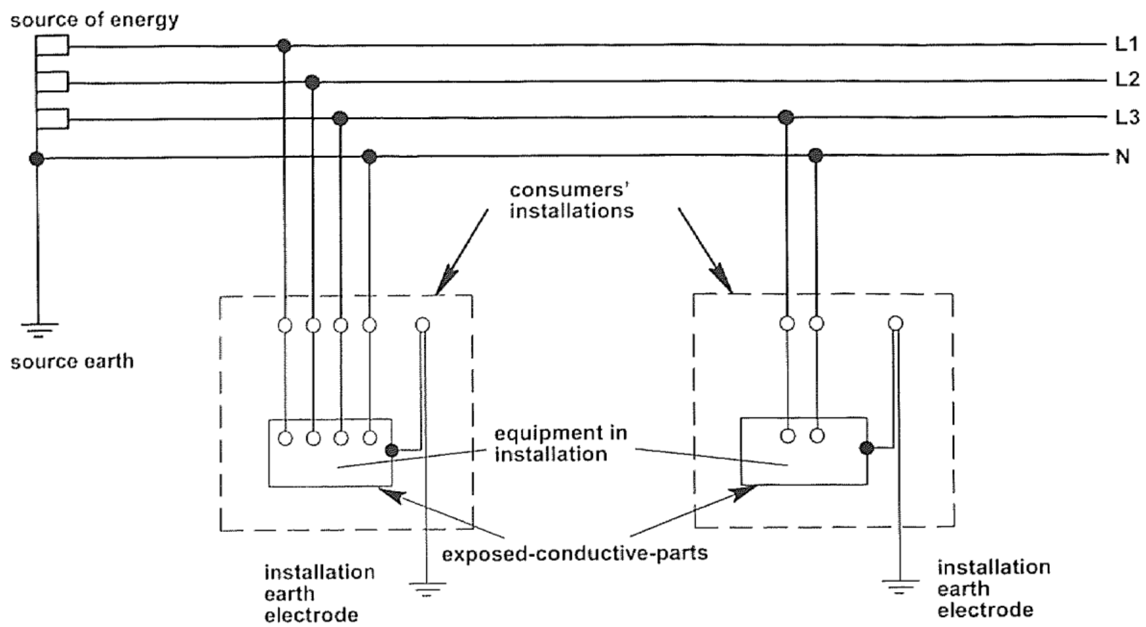

Figure 7.2.2.1 Schematic Diagram of TT-Earthing System

Table 7.2.2.1

Nominal Voltage	Operational Voltages	
	Minimum - kV (pu)	**Maximum** - kV (pu)
33kV	**31(0.94)**	**34.98(1.06)**
16kV	**15.2(0.95)**	**16.8(1.05)**
11kV	**10.45(0.95)**	**11.55(1.05)**
400V	**390.1(0.94)**	**439.9(1.06)**
230V	**216.2(0.94)**	**243.8(1.06)**

7.3.1.2 The indoor wiring shall contain protective earthing conductors beforehand to ensure the earthing of electric equipment.

7.3.2 Indoor Wiring Cables

The indoor wiring cables shall be chosen to meet each user's site specifications by relying on Standards codified under 7.2.1.12 and where any user's site specific requirements are not met by the Standards contained herein, the relevant NIS IEC Standards shall apply.

7.3.2.1 Materials and Types of Cables

7.3.2.1.1 All cable conductors for internal wiring other than the outer conductors of earthed concentric systems shall be of annealed copper, and shall conform to NIS IEC 60228.

7.3.2.1.2 Every non-flexible cable for use as fixed wiring operating at low and medium voltages shall comply with the relevant NIS and shall be selected from one of the following types:

a. Non-armoured PVC insulated cables; NIS NIS IEC 60227-3

b. Armored PVC insulated cables; NIS IEC 60502-1
c. Split-concentric copper-conductor PVC insulated cables; NIS IEC 61089
d. Rubber insulated cables; NIS IEC 60245-1
e. Impregnated-paper-insulated, lead-sheathed or aluminum sheathed cables; NIS IEC 60055-2
f. Mineral-insulated metal-sheathed cables; NIS IEC 60702-1
g. XLPE cables; NIS IEC 60502-1 and
h. Any other non-flexible cable that complies with applicable NIS IEC standards.

In non-flexible cables of every type, conductors of cross-sectional area 10 mm^2 or less shall be of copper or copper-clad aluminum. Any of the types of cable sheathed with PVC or lead, or having a Heat Resistant Fire Retardant (HRFR) sheath, if intended for aerial suspension, may incorporate a catenary wire.

7.3.2.1.3 Bus bars and bus-bar connections on switchboards shall comply with NIS NIS IEC 60439-2. The requirement does not apply to a bus-bar trunking system.

7.3.2.1.4 Every conductor for use as an overhead line within a User's site shall comply with the relevant NIS and shall be selected from one of the following types:

a. Hard-drawn copper or cadmium-copper conductors; NIS NIS IEC 61089
b. Hard-drawn aluminium and steel-cored aluminium conductors; NIS NIS IEC 60889
c. Aluminium-alloy conductors; NIS NIS IEC 61089
d. Insulated aluminium conductors for overhead power lines; NIS NIS IEC 60227-1 and
e. Any other conductor that complies with applicable NIS IEC standards.

7.3.2.1.5 The insulation of every flexible cable and flexible cord shall comply with the relevant NIS and shall be selected from one of the following types:

a. Insulated flexible cords; NIS NIS IEC 60227-5
b. Rubber insulated flexible cables; NIS NIS IEC 60245-1
c. PVC insulated flexible cables (non-Armoured); NIS NIS IEC 60227-3
d. Braided traveling cable for lifts; NIS NIS IEC 60245-5 and
e. Rubber-insulated flexible trailing cables for quarries and miscellaneous mines NIS NIS IEC 60245-1. Such rubber insulated flexible cables and flexible cords, may incorporate flexible armour of galvanized steel or phosphor bronze, or a screen of tinned copper-wire braid.
f. Any other flexible cable with insulation complying with applicable NIS IEC standards.

Provided this Regulation does not apply to a flexible cord forming part of a portable appliance or light fitting where the appliance or light fitting as a whole is a special flexible cable and flexible cord for combined power and telecommunication wiring.

7.3.2.1.6 All cables, including flexible cables and flexible cords, for use at extra-low voltage shall comply with the applicable NIS.

7.3.2.2 Types of Insulation

7.3.2.2.1 The type of insulation and protective covering if any, of every cable for fixed wiring shall be selected so as to allow compliance with the requirements of this Section as a precaution against mechanical damage or damage by heat, fire or explosion, damp and corrosion.

7.3.2.2.2 Cables insulated and/or sheathed with general-purpose PVC shall not be installed in refrigerated spaces or other situations where the temperature is considered consistently below 0°C.

7.3.2.2.3 Every flexible cable and flexible cord shall be selected from one of the following types:

a. Braided circular cable;
b. Un-kinkable cable;
c. Circular sheathed cable;
d. Flat-twin sheathed cable;
e. Braided circular twin and three-core, cable insulated with fiberglass.

N.B. Provided that these types shall be used only in dry situations for light fitting or for other applications where the cord is not subject to abrasion or undue flexing.

7.3.2.2.4 Flexible cables and flexible cords, where they are exposed to risk of mechanical damage, shall as a minimum be of a type sheathed with rubber or PVC and where necessary shall also be armoured.

7.3.2.2.5 Flexible cables and flexible cords, which in normal use are exposed, to risk of contact with water shall be of a type sheathed with rubber or PVC.

7.3.2.2.6 Where flexible cables or flexible cords are exposed to risk of contact with oil or petrol, or where the cable that will not support combustion is required, cables or cords having a PVC, HRFR or oil resisting and flame retardant sheath shall be used as appropriate.

7.3.2.3 Voltage Rating

The voltage rating of every cable shall not be less than the declared or the nominal voltage of the circuit.

7.3.2.4 Conductor Sizes

7.3.2.4.1 The size of every bare conductor or cable conductor shall be such that its current rating as stated in Tables 7.2.3.4.1(a) to (c) after the application of any factors appropriate to the type of cable, the conditions of installation, and the class of excess-current protection provided it is not less than the maximum sustained current which will normally flow through it. This standard does not apply to certain conductors on switchboards

Table 7.2.3.4.1a

Single-circuit current ratings and associated voltage drops for single core p.v.c insulated cables
Non-armoured, with or without sheath
(Copper, conductors)
1.0mm2 to 35 mm2
The rating tabulated applies where cable is provided with coarse excess-current protection (see item 2 (b) of the preface) for close excess-current protection, see rating factor below.

Conductor		Bunched and enclosed In conduit of trucking**				Clipped direct to a surface or a cable Tray, bunched and unenclosed			
		2cables, single Phase a.c. or d.c		3 or 4 cables Three- phase a.c		2 cables, single. Phase a.c or d.c		3 or 4 cables, Three-phase a.c	
Normal Cross-sectional Area	No. And dis (mm) of wires (Seminal)	Current Rating	Voltage drop Per ampere Per meter	Current Rating	Voltage drop Per ampere Per meter	Current Rating	Voltage drop Per ampere Per meter	Current Rating	Voltage drop Per ampere Per meter
1	2	3	4	5	6	7	8	9	10
mm²	1	A	mV	A	mV	A	mV	A	mV
1	1/1.13	11	40	9	35	13	40	12	35
1.5	1/1.38	13	27	11	23		27		23
	7/0.50		30		26	16	30	15	2.6
2.5	1/1.78								
	7/0.67	18	16	16	14	23	16	20	14
4	7/0.85	24	10	22	88	30	10	27	8.8
6	7/1.04	31	68	28	5.9	38	6.8	34	5.9
10	7/1.35	42	40	39	3.5	51	4	46	3.5
16	7/1.70	56	26	50	2.2	63	2.6	61	2.2
25	7/2.14	73	16	66	1.4	89	1.6	80	1.4
35	7/2.53	90	12	80	1	109	1.2	98	1

Total volt drop between the consumer's and any other point in the installation must not exceed 2.5% of the nominal voltage. The rating in columns 3 and 5 relate to cables in metal non- metallic conduct and trucking.

RATING FACTORS
FOR CLASS OF EXCESS-CURRENT PROTECTION
1.33 may multiply the rating tabulated where there close excess current protection can be assured

Table 7.2.3.4.1b

FOR AMBIENT TEMPERATURE

Ambient Temperature	25°C	35°C	40°C	45°C	50°C	55°C	60°C	65°C
Rating factors for cables having coarse excess-current protection	102	0.97	0.94	0.91	0.88	0.77	0.63	0.44
Rating factor for cables having close excess-current protection	106	0.94	0.87	0.79	0.71	0.61	0.5	0.35

FOR GROUPS
For group circuits unenclosed, the single circuit rating apply provided that
The horizontal clearance between circuit is

(a) not less than 6 items the coverall diameter of an individual cable, and
(b) not less than the overall width of an individual circuit
-except that the horizontal clearance need not in any case exceed 150 mm, and

(2) The vertical clearance between circuit is not less than 150mm, and
(3) if the number of circuit exceeds 4, they are installed in a horizontal phone.

In the other cases, unless a more precise evaluation current rating has been made based on experimental work or calculated data, the following factors are applicable

Table 7.2.3.4.1c

No. of circuits (pairs of cables single-phase a.c. or d.c 3 cables per circuit or 4 where one is the neutral 3-phase a. c.	2	3	4	5	6	8	10	12	14	16**	18**	20**
Rating Factor	0.80	0.69	0.62	0.59	0.55	0.51	0.48	0.43	0.41	0.39	0.33	0.36

** Not applicable to 3-phase.
P .V.C non- armored single-core (50mm^2 to 630 mm^2)
(COPPER)

7.3.2.4.2 No cable having a conductor of nominal cross-sectional area less than 1.5 mm^2 and flexible cord having a conductor of nominal cross sectional area less than 0.75 mm^2 shall be used in User Site Installations.

7.3.2.4.3 Mains service cable shall be stranded, and have a current carrying capacity of not less than the maximum demand for the installation. In no case shall the cable be smaller than 6mm^2.

7.3.2.5 Load Assessment

7.3.2.5.1 If load assessment is not readily available for a user's site, it shall be assessed according to the following user 's site classifications:

a. Urban areas comprising: -

i.	Low Density Residential Areas:	50-85VA /m^2;
ii.	High Density Residential Areas:	20-30 VA/m^2;
iii.	Residential High-Rise Buildings:	60-75VA /m^2;
iv.	Commercial High-Rise Buildings:	70-80VA /m^2;
v.	Housing Estates:	50-70VA /m^2;
vi.	Parks/Amusements	50-70VA /m^2
vii.	Urban Slum	10-15VA/m^2

b. Semi-Urban Areas: -

i.	Residential Areas:	30-50VA /m^2;
ii.	Local Government Headquarters	25-50VA /m^2
iii.	Hospitals	30-70VA /m^2
iv.	Small and Medium Enterprises	30-50VA /m^2

c. Rural Areas: -

i.	Lighting/Essential Appliances	30-50VA /m^2
ii.	Clinics	30-50VA /m^2
iii.	Boreholes	0.75-3.5kVA
iv.	Small Business Enterprises	25-35VA/m^2

d.	Industrial Complexes: -	
i.	Large Industries	50-200MVA
ii.	Medium industries	1.0-50MVA
iii.	Small Industries	0.1-1MVA
e.	Commercial Loads	
i.	Large shopping complex loads	0.1-1MVA
ii.	Media (Print and Electronic)	0.25-1.5MVA
iii.	Hotels (large, medium and small)	0.05-2.5MVA
iv.	Entertainment Centres	5-100kVA
f.	Municipal Loads	
i.	Streetlights & Traffic Lights	30-100VA/installation
ii.	Waterworks	0.5-20MVA
iii.	Educational Institutions	30-100VA/m2
iv.	Boreholes	250-2000VA/borehole
v.	Offices	45-150VA/m2
g.	Agricultural Loads	
i.	Irrigation	1-10kVA/pump motor
ii.	Agricultural Processing	5-800kVA
iii.	Storage Facilities (Silos)	50-1000kVA
iv.	Cold Storage facilities	100-200VA/m2
h.	Large Infrastructures	
i.	Domestic Airports	0.5-2.0MVA
ii.	International Airports	10-50MVA
iii.	Seaports	30-75MVA

The above stated procedural guidelines for load assessment shall be subject to appropriate review to capture penetration of future energy efficient lighting system, appliances and heavy industrial equipment and to the extent permitted by superior judgment of the design engineer.

7.3.2.5.2 The load assessment of a building area in a user's site shall be for all the floors as per plan or as actually constructed, whichever is higher.

7.3.2.5.3 Where electrical energy is used for more than one purpose in a user's site, the maximum load demand shall be appropriately computed from the various loads assessed and applicable diversity factor as decided upon by the design engineer using Table 7.2.3.5.3

Table 7.2.3.5.3

Allowance for diversity Estimation of the maximum current, which will normally flow in an installation for use in calculating the size of cables and switchgear except for final sub-circuits

Purpose of final sub-circuits fed from the wiring to which diversity applies		***Types of installation***			
		Individual domestic installation including Individual flats of a block	***Block of residential flats***	***Hotel, boarding houses, lodging houses, etc***	***Shops, etc e.g. offices and business premises, other than Factories***
1.	Lighting	66%	50%	75%	90%
2.	Heating and power appliances (but see 3-8 below)	100% fl up to 10 amperes	100% fl of the largest appliance	100% fl of the largest appliance	100% fl of the largest appliance
		+50% of any load in excess of 10 amperes	+50% fl of 2nd largest appliance	+80% fl of 2nd largest appliance	+75% fl of remaining appliance
		Appliance	+33% fl of 3rd largest appliance	+60% fl of remaining appliances	
			+20% of remaining appliance		
3.	Cooking appliances permanently connected	10 amperes	100% fl of largest appliance	100% fl of largest appliance	100% fl of largest appliance
		30% fl of connected cooking appliances in excess of 10 amperes	+50% fl of 2nd largest appliance	+80% fl of 2nd largest appliance	+80% fl of 2nd largest appliance
		+5 ampere if socket-outlet incorporated in unit	+33% fl of 3rd largest appliance	+80% fl of 2nd largest appliance	+80% fl of 2nd largest appliance
			+25% fl of 4th largest appliance		
			+20% of remaining appliances		
4.	Motors other than lift motors which are subject to special conditions	NO DIVERSITY ALLOWED		100% fl of the largest motor	100% fl of the largest motor
				+50% fl of remaining motors	80% fl of 2nd largest motors
5.	Water heaters (instantaneous type)	100% fl of the largest appliance		To be assessed by a competent person	
		150% fl of 2nd largest appliance		To be assessed by a competent person	
		+25% of remaining appliances		To be assessed by a competent person	
6.	Water heaters (thermostatically controlled)	NO DIVERSITY ALLOWED **			
7.	Socket-outlets and stationery appliances in accordance with Table	100% largest fuse or circuit-breaker rating of individual circuits	100% largest fuse or circuit-breaker rating of individual circuits	100% largest fuse or circuit-breaker rating of individual circuits	100% largest fuse or circuit-breaker rating of individual circuits
		+40% sum of fuse or circuit-breaker rating of other circuits	+40% sum of fuse or circuit-breaker rating of other circuits	+50% sum of fuse or circuit-breaker rating of other circuits	+40% sum of fuse or circuit-breaker rating of other circuits
8.	Socket-outlet and stationery appliances other than those listed above	100% fl of largest point	100% fl of largest point	100% fl of largest point	100% fl of largest point
		40% fl of other points	40% fl of other points	75% fl of points in main rooms (dining room, etc)	75% fl of other points
				40% fl of remaining points	

*For the purpose of this Table, an instantaneous water-heater is deemed to be water-heater of any loading, which heats water only whil*e the tap, is turned on and therefore uses electricity intermittently.*

***It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity.*

7.3.2.5.4 Other special loads of a user site that meet the approval of the supply authority shall be appropriately assessed in accordance with relevant Standards.

7.3.2.5.5 It shall be the responsibility of the design engineer to provide each user's site load limiter of suitable capacity in accordance with the actual assessed maximum demand of users' sites. The load limiter shall only be accessible to authorized persons and under no circumstance shall modifications be made to the approved user's site installation without prior approval given by the electricity distribution company.

7.3.2.5.6 After electrical installation work has been duly certified and approved at the user's site, any modification that may involve addition or alteration to the existing installation, beyond replacement of lamps (preferably by energy efficient lamps), weather sensitive efficient appliances, fuses, switches and other replaceable component parts of the installations which in no way increase the installation capacity, shall not be carried out in the user's site unless:

a. Such modification is approved by the electricity distribution company and
b. Duly carried out by a competent COREN Registered Engineering Personnel.

7.3.2.6 Specification for Earth Continuity Conductors and Allowable Voltage Drop

7.3.2.6.1 Every conductor used as earth continuity conductors shall have cross-sectional area of not less than the cross-sectional area of the largest live conductor but in any case not less than $1.5mm^2$.

7.3.2.6.2 Cables connected in parallel shall be of the same type, size and length, to ensure proper division of the current.

7.3.2.6.3 The size of every conductor approved for indoor wiring shall be such that the drop in voltage from the consumer's terminals to any point in the installation does not exceed 2.5% of the rated nominal voltage when the conductors are carrying the full load current, but disregarding starting conditions of appliances driven by motors. This requirement shall not apply to wiring fed from an extra-low voltage secondary of a transformer.

7.3.2.6.4 Where allowance is made for diversity, it may be taken into account in calculating voltage drop.

7.3.2.6.5 The earthing-lead shall be stranded copper cable or flat copper, the latter not less than 19 mm by 3 mm. No conductor of a cross-sectional area less than 6mm2 shall be used as an earthing lead.

7.3.2.7 Protection against Damage

7.3.2.7.1 All conductors and cables shall be adequately protected against any risk of mechanical damage to which they may be exposed in normal conditions of service.

7.3.2.7.2 Where cables pass through holes in metalwork, precautions shall be taken to prevent abrasion of the cables on any sharp edges.

7.3.2.7.3 Non-sheathed cables shall be protected by enclosure in conduit, duct or trunking.

7.3.2.7.4 Cables shall not be run in a lift (or hoist) shaft unless they form a part of the lift installation. Cables of lift installations, other than traveling cables, in such a shaft shall be:

a. Armoured;
b. Mineral-insulated, metal-sheathed;
c. Of a type having HRFR or ORFR; or
d. Enclosed in metal conduit, duct or trunking, high impact rigid PVC conduit, or otherwise effectively protected against mechanical damage.

7.3.2.8 Cable Bending

The internal radius of every bend in a cable shall be not less than the appropriate value stated in Table 7.2.3.8.

Table 7.2.3.8

Minimum internal radius of bends in cables for fixing wiring

Insulation	***Finish***	***Overall diameter***	***Factor to be applied to overall diameter of cable to determine minimum internal radius of bend***
Rubber or p.v.c.(circular copper or circular standard aluminum conductors)		Not exceeding 10mm Exceeding 10mm but not exceeding 35mm… Exceeding 25mm………	3 4 6 6
p.v.c.(solid aluminum or shaped copper conductors)	Armored or non-armored	Any Other	8
Impregnated paper	Lead or corrugated aluminium sheath with or without armour	Any Other	12
Mineral	Smooth aluminium sheath with or without armour Copper or aluminium sheath with or without p.v.c covering	Not exceeding 30mm Exceeding 30mm but not 50mm Exceeding 50mm Any Other	12 15 18 6

**The factors are applied to the diameter over the aluminum sheath.*

7.3.2.9 Cable Supports

Every cable installed in or on a building shall be supported by one of the methods described from Clause 7.2.3.9.1 to 7.2.3.9.12. Supports shall be so arranged that there is no appropriate mechanical strain on any cable termination as follows:

7.3.2.9.1 For non-sheathed cable, installation in conduit without further fixing of the cables, provided that precautions are taken against undue compression of the installation at the top of any vertical runs exceeding 5 m in length.

7.3.2.9.2 For non-sheathed cables, installation in trunking without further fixing of the cables, provided that vertical runs shall not exceed 5m in length without intermediate support.

7.3.2.9.3 For sheathed and/or armoured cables installed in accessible positions shall be supported by clips at appropriate intervals.

7.3.2.9.4 For cables of any type, resting without fixing in horizontal runs of ducts or trunking,

7.3.2.9.5 For sheathed and/or armoured cables installed in horizontal runs, which are inaccessible and unlikely, to be disturbed shall rest without fixing on part of a building provided that the surface is dry and reasonably smooth.

7.3.2.9.6 For sheathed-and-armoured cables in vertical runs, which are inaccessible and unlikely to be disturbed, shall be supported at the top of the run by a clip and a round support of a radius not less than the appropriate value stated in Table 7.2.3.8.

7.3.2.9.7 For sheathed cables without armour in vertical runs which are inaccessible and unlikely to be disturbed, support by the method described in 6 above shall apply provided that the length of run without intermediate support shall not exceed 2m for a lead/sheathed cable or 5m for a rubber or PVC sheathed cable.

7.3.2.9.8 For rubber or PVC sheathed cables, installation in conduit without further fixing of the cables shall apply provided that any vertical run shall be in conduit of suitable size and shall not exceed 5m in length.

7.3.2.9.9 For rubber or PVC sheathed cables installed as surface wiring, clips shall be spaced at intervals not exceeding 200 mm.

7.3.2.9.10 Support by a catenary wire incorporated in the cable during manufacture shall be sufficient provided that the spacings between supports shall not exceed those stated by the manufacturer.

7.3.2.9.11 For flexible cords used as pendants, attachment to a ceiling rose or similar accessory by the cord-grip or other method of strain relief provided in the accessory shall apply.

7.3.2.9.12 For cables of the types described in Standard 7.2.3.7.4 (a) and (c) support by clips at spacing shall not exceed 1m.

7.3.2.10 Protection against Heat

Every cable shall be so selected and installed as to be suitable for operation under such ambient temperatures of its surroundings as are likely to occur, which shall not exceed the appropriate value stated by the manufacturer, account being taken of any transfer of heat from any accessory, appliance (e.g. immersion heater or other appliance) or lighting fitting to which cable or flexible cord is connected.

7.3.2.11 Flammable and Explosive Locations

7.3.2.11.1 If it is necessary to install cables in a situation where flammable and/or explosive dust, flammable volatile liquid or vapour or gas is likely to be present, or where explosive materials are handled or stored, one or more of the following types of wiring systems shall be used:

a. cables in solid-drawn or seam-welded conduit,
b. lead-sheathed, steel-armoured cable,
c. mineral insulated cable or copper-sheathed cable,
d. armoured PVC insulated cable having an overall extruded covering of PVC.

Provided that this type of cable shall not be directly buried in the ground, which may be contaminated by flammable volatile liquid.

This standard does not apply to cables of intrinsically - safe circuits; nor does it apply to adequately ventilated battery rooms or garages.

7.3.2.11.2 Where cables, conduits, ducts or trunking pass through floors, walls, partitions or ceilings, the surrounding hole shall be made good with cement or similar fire-resisting material to the full thickness of the floor, wall and space through which fire or smoke might spread shall not be left around the cable, conduit, duct or trunking. In addition, where cables, conduits or conductors are installed in channels, ducts, trunking, or shafts which pass through floors, walls, partitions or ceilings, suitable internal fire-resisting barriers shall be provided to prevent the spread of fire.

7.3.2.12 Damp and Corrosive Situations

7.3.2.12.1 Every cable shall be installed where it will not be exposed to rain, dripping water, condensed water, accumulations of water or oil, or corrosive substances or shall be of a type designed to withstand such conditions.

7.3.2.12.2 In damp situations and wherever they are exposed to the weather, all metal sheaths and armour of cables, metal conduit, duct, or trunking, and clips and their fixings, shall be of corrosion-resistant material or finish and shall not be placed in contact with other metals with which they are likely to set up electrolytic action; conduit, if of steel shall be galvanized heavy-gauge.

7.3.2.12.3 Armoured PVC insulated cables and mineral-insulated metal-sheathed cables installed in damp situations or in concrete ducts or wherever exposed to the weather or other risk of corrosion, shall be of a type having an overall extruded covering of PVC.

7.3.2.12.4 Aluminum-sheathed cables installed in underground pipes or in concrete ducts shall be provided with a corrosion-resistant finish.

7.3.2.13 Segregation of Circuits

Where an installation comprises extra low-voltage or telecommunication or fire-alarm circuits, as well as circuits operating at low voltage and connected directly to a mains supply system, precautions shall be taken, to prevent electrical contact between the cables of the various circuits.

7.3.2.13.1 Types of circuits described in 7.2.3.13 are divided into categories as follows:

a. **Category I circuits**: Circuits (other than fire alarm circuits) operating at low voltage and supplied directly from a mains supply system.
b. **Category II circuits**: With the exception of fire-alarm circuits, all extra low-voltage circuits; telecommunication circuits (e.g., radio, telephone, sound-distribution, burglar-alarm, CCTV, Cable TV, bell and call circuits), which are not supplied directly from a mains supply system.
c. **Category III circuits**: Fire-alarm/smoke detector circuits.

7.3.2.13.2 Cables of Category I circuits shall not be drawn into the same conduit or duct as cables of Category II circuits, unless the latter cables are insulated in accordance with the requirements of these standards for the highest voltage present in the Category I circuits.

7.3.2.13.3 Cables of Category I circuits shall not in any circumstance be drawn into the same conduit or duct as cables of Category III circuits.

7.3.2.13.4 Where a common channel or trunking is used to contain cables of Category I circuits, and Category II circuits, all cables connected to Category I circuits, shall be effectively partitioned from the cables of the Category II circuits, or alternatively the latter cables shall be insulated in accordance with the requirements of these Standards for the highest voltage present in the Category I circuits.

7.3.2.13.5 Where a common channel or trunking is used to contain cables of Category I and Category III circuits, the two Categories of circuits shall be separated by continuous partitions of fire-resistant material; this requirement shall not apply where the Category III circuits are wired in mineral-insulated metal-sheathed cable. In conduit, duct, or trunking systems, where controls or outlets for Category I and Category II circuits are mounted in or on common boxes, switch-plates or blocks, the cables and connections and the two Categories of circuits shall be partitioned by means of rigid fixed screens or barriers. At any common outlets in a trunking system for Category I and Category III circuits, the two categories of circuits shall be separated by continuous partitions of fire resisting material.

7.3.2.13.6 Where cores of Category I and Category II circuits are contained in a common multi-core cable, flexible cable or flexible cord, the cores of the Category II circuits shall be insulated individually or collectively as a group, in accordance with the requirements of these Standards, for the highest voltage present in the Category I circuits, or alternatively shall be separated from the cores of the Category I circuits by an earthed metal braid of equivalent current-carrying capacity to that of the cores of the Category I circuits.

7.3.2.13.7 Where terminations of the two categories of circuits are mounted in or on common boxes, switch-plates or blocks, they shall be partitioned in accordance with Clause 7.2.3.13.8 or alternatively be mounted on separated and distinct terminal blocks adequately marked to indicate their functions.

7.3.2.13.8 Cores of Category I and Category III circuits shall not in any circumstances be contained in a common multi-core cable, flexible cable or cord.

7.3.2.13.9 Metal sheaths and armour of all cables operating at low voltage, and metal conduits, ducts and trunking and bare earth-continuity conductors associated with such cables; which might otherwise come into fortuitous contact with other fixed metalwork shall be either effectively segregated therefrom, or effectively bonded thereto so as to prevent appreciable voltage differences at such possible points of contact.

7.3.2.13.10 Current carrying conductors/cables shall not be installed in the same conduit or trunking as pipes or tubes of non-electrical services e.g. air, gas, oil or water.

7.3.2.14 Identification of Conductors

Every non-flexible single-core, twin or multi-core cable for use as fixed wiring and bare conductors shall be identifiable at its terminations and preferably throughout its length, by the appropriate methods described in Clauses 7.2.3.14. to 7.2.3.14.5. These provisions do not apply to special cables designed for heating.

7.3.2.14.1 The identification of conductors for non-flexible cables shall be as follows:

a. For rubber and PVC insulated cables, the use of core colours in accordance with the requirements of Table 7.2.3.14A or the application at termination of sleeves or discs of the appropriate colours prescribed in the table.

b. For armoured PVC insulated cables as an alternative to the method described in item (a) above, the use of numbered cores, provided that the numbers 1, 2 and 3 shall signify live conductors, the number 0 the neutral conductor, and the number 4 the fifth (special-purpose) core, if any.

c. For paper-insulated cables, the use of numbered cores, provided that the numbers 1, 2 and 3 shall signify live conductors, the number 0 the neutral conductor, and the number 4 the fifth (special-purpose) core, if any.

d. For mineral-insulated cables, the application at terminations of sleeves or discs of the appropriate colours prescribed in Table 7.2.3.14A.

7.3.2.14.2 Bare conductors shall be made identifiable where necessary by the application of sleeves or discs of the appropriate colours prescribed in Table 7.2.3.14A or by painting with those colours.

7.3.2.14.3 Any scheme of colouring used in a consumer's installation to identify switchboard bus bars or poles shall comply with the requirements of Table 7.2.3.14A so far as these are applicable.

7.3.2.14.4 The cores of every flexible cable including a flexible cord shall be coloured throughout in accordance with the requirements of Table 7.2.3.14B

7.3.2.14.5 The colour combination, green and yellow is reserved exclusively for identification of earthing conductors and shall not be used for any other purpose. This provision does not apply to PVC installed parallel-twin non-sheathed flexible cords.

7.3.2.14.6 Flexible cables or flexible cords having the following core colours shall not be used; green alone; yellow alone; or any bi-colour other than the colour combination green-and-yellow mentioned in Clause 7.2.3.14.4.

Table 7.2.3.14A

Colour Identification of cores of non-flexible cables and bare conductors for fixed wiring

Function	Colour identification of core of rubber or PVC insulated non flexible cable or of sleeve or disc to be applied to be conductors or cable core
Earthing	Green and yellow
Live of a.c single-phase circuit	Red or yellow or brown or blue
Neutral of a.c single or three-phase	Black
Phase R of 3 phase a.c circuit	Red
Phase y of 3-phase a.c circuit	Yellow
Phase B of 3 phase a.c circuit	Blue
Positive of d.c 2-wire circuit	Red
Negative of d.c 2-wire circuit	Black
Outer (positive or negative) of d.c 2-wire circuit from 3-wire system	Red
Positive of 3-wire d.c circuit	Red
Middle of 3-wire d.c circuit	Black
Negative of 3-wire d.c circuit	Blue
Fifth (special purpose) core in 5-core armoured PVC cable	Orange

Table 7.2.3.14B

Colour identification of cores of flexible cables and flexible cords

Number of cores	Function of core	Colour(s) of cores
1	Live Neutral Earthing	Brown (a) Blue Green and Yellow
2	Live Neutral	Brown Blue (b)
3	Live Neutral Earthing	Brown (c) Blue (b) Green and Yellow
4 or 5	Live Neutral Earthing	Brown or Black (d) (c) Blue (b) Green and Yellow

7.3.2.15 Terminations

7.3.2.15.1 All terminations of cable conductors and bare conductors shall be mechanically sound and electrically continuous.

7.3.2.15.2 Every connection at a cable termination shall be made by means of a terminal, soldering socket, or compression-type socket; shall securely contain and anchor all the wires of the conductor, and shall not impose any appreciable mechanical strain on the terminal or socket.

7.3.2.15.3 An aluminum conductor shall not be placed in contact with a terminal of brass or other metal having a high copper content, unless the terminal is suitably plated or other suitable precautions are taken to prevent corrosion.

7.3.2.15.4 At every cable termination, the insulation shall be removed no further than is necessary for compliance with Clause 7.2.3.15.2.

7.3.2.15.5 At every cable termination, any braid, tape, sheath, or armour over the insulation shall be cut back from the end of the insulation, as may be necessary to prevent undue leakage from live parts of the braid, tape, sheath, or armour. This provision does not apply to mineral-insulated cables.

7.3.2.15.6 In any situation, the exposed conductor and insulation of cables insulated with impregnated paper shall be protected from ingress of moisture by being suitably sealed.

7.3.2.15.7 The ends of mineral-insulated metal-sheathed cables shall be protected from moisture by being suitably sealed and the insulation shall be thoroughly dry before the sealing material is applied. Such sealing material, and any material used to insulate the conductors where they emerge from the insulation, shall have adequate insulating and moisture proofing properties, and shall retain these properties through the range of temperatures to which the cable shall be subjected.

7.3.2.15.8 Soldering fluxes, which remain acidic or corrosive at the completion of the soldering operation, shall not be used.

7.3.2.15.9 Where a non-metallic outlet box of thermoplastic material (e.g. PVC) is used for the suspension of, or is in contact with, a light fitting, care shall be taken to ensure that the temperature of the box does not exceed 60oC. The mass suspended from the box shall not exceed 3 kg.

7.3.2.15.10 The termination of cables in a situation where flammable and/or explosive dust, flammable volatile liquid vapour or gas is likely to be present, or where explosive materials are handled or stored, shall be avoided wherever possible. Otherwise, terminations shall be enclosed in a flameproof fitting or alternatively, where methods are employed for avoiding the explosion hazard other than by the use of flameproof equipment the terminations shall be enclosed in a box suitable for such use.

7.3.2.15.11 Cable glands shall securely retain the outer sheath or armour of the cables without damage to these, and where necessary shall incorporate adequate means of maintaining earth continuity between the sheath or armour and the threaded fixing component of the gland.

7.3.2.16 Cable Joints

7.3.2.16.1 Where joints in cable conductors and bare conductors are necessary, they shall be mechanically sound and electrically continuous. Joints in non-flexible cables shall be accessible for inspection provided that this requirement shall not apply to joints in cables buried underground, or joints buried or enclosed in non-combustible building material so that no danger can arise. Joints in non-flexible cables shall be made by either soldering, brazing, welding, or mechanical clamps, or be of the compression type; provided that mechanical clamps shall not be used for, inaccessible joints buried or enclosed in the building structure. All mechanical clamps and compression-type sockets shall securely retain all the wires of the conductors.

7.3.2.16.2 Every joint in a cable shall be provided with insulation not less effective than that of the cable cores and shall be protected against moisture and mechanical damage. Soldering fluxes which remain acidic or corrosive at completion of soldering operation shall not be used.

7.3.2.16.3 For joints in paper-insulated metal-sheathed cables, a wiped metal sleeve or joints box, filled with insulating compound, shall be provided.

7.3.2.17 Metal Sheathed and Armoured Cables

7.3.2.17.1 All metal sheaths and cable armouring and associated accessories shall be earthed in accordance with these Standards.

7.3.2.17.2 Where non-metal joints boxes are used with metal-sheath and, or armoured cables, the continuity shall be maintained by a metal bonding strip or similar means having a resistance not higher than that of an equivalent length of metal cable sheath or, (for armoured non-metal sheathed cables), the armour of the largest cable entering the box.

7.3.2.18 Paper Insulated Cables

Paper insulated cables shall be of a non-draining type which will comply with the requirements of NIS NIS IEC 60055-1, where migration of the impregnating compound would otherwise be liable to occur.

7.3.2.19 Conduit Systems

7.3.2.19.1 The conduits for each User's site shall be completely erected before any cable is drawn in. This requirement does not apply to prefabricated flexible conduit systems which are not wired in-situ.

7.3.2.19.2 Conduits shall be securely fixed, and where they are liable to mechanical damage they shall be adequately protected.

7.3.2.19.3 Inspection type conduit fittings such as inspection boxes, draw boxes, bends, elbows, and toes, shall be so installed that they can remain accessible for such purposes as the withdrawal of existing cables or the installing of additional cables.

7.3.2.19.4 The number of single core rubber insulated, braided and compounded cable, of PVC insulated non-sheathed cables run in one conduit shall be such as to permit easy drawing in. The number of cables drawn in shall not be greater than the appropriate number given in Table 7.2.3.20A or Table 7.2.3.20B of schedule I as applicable.

7.3.2.19.5 For types of cables having large overall diameters than those shown in the table, appropriate reduction shall be made in the number of cables drawn in.

7.3.2.19.6 For groups of cables other than those provided in Table 7.2.3.20A and Table 7.2.3.20B the number and sizes of the cables installed shall be such that a space factor of 40% is not exceeded.

7.3.2.19.7 The numbers stated in the tables; and the space factor of 40% relate to conduit runs incorporating not more than two 90˚ bends or radius not less than that specified for normal bends or for runs having more bends than this or having opposing adjacent bends for runs containing additional sets or other restrictions, appropriate reduction shall be made in the number of cables installed.

Table 7.2.3.20A: Capabilities of Steel Conduits

Maximum capabilities of steel conduits, for the simultaneous drawing in of single core p.v.c cables or rubber cables

Cable Size			**Conduit Size and Gauge**							
Nominal Conductor Size mm^2	Number and diameter of wire No/mm^2	Nominal overall Diameter mm	16mm or 5/8 in		20 mm or ¾ in		25 mm or 1 in		32 mm or $1^{1/4}$ in	
P.V.C cables Metric Light			Metric Light	Metric Light	Metric Light	Metric Light	Metric Light	Metric Light	Metric Light	Metric Light
			Maximum number of cables							
1	1/1.13	2.9	8	7	13	12	22	19	38	35
1.5	1/1.38	3.1	7	6	12	10	19	17	33	31
1.5	7/0.50	3.3	6	5	11	10	18	16	31	28
2.5	7/1.78	3.5	5	4	9	8	15	13	26	24
2.5	7/0.67	3.8	4	4	8	7	13	11	22	20
4	7/0.85	4.3	3	3	6	5	10	9	17	16
6	7/1.04	4.9	3	2	5	4	7	7	13	12
10	7/1.35	6.2	-	-	3	2	4	4	8	7

16	7/1.70	7.1	-	-	2	-	3	3	6	5
25	7/1.24	9	-	-	-	-	2	2	4	4
35	19/1.53	10.1	-	-	-	-	-	-	3	2
50	19/1.78	12	-	-	-	-	-	-	2	2
	Rubber cables									
1	1/1.13	3.4	6	5	10	8	16	14	28	25
1.5	1/1.38	3.6	5	4	9	8	14	13	27	23
2.5	1/1.78	4	4	3	7	6	11	10	20	18
4	7/0.85	5.2	2	2	4	3	7	6	12	11
6	7/1.04	6	2	-	3	2	5	4	9	8
10	7/1.35	7.3	-	-	2	-	3	3	6	5
16	7/1.70	8.4	-	-	-	-	2	2	4	4
25	7/2.14	10.1	-	-	-	-	-	-	3	2
35	19/1.53	11.7	-	-	-	-	-	-	2	2

Note; The maximum numbers of cables in the table related to conduit runs incorporating not more than two 90^0 bends or the equivalent. Where runs include additional bends, sets or other restrictions, the numbers must be appropriately reduced. This applies particularly where solid conductor cables are to be drawn

Table 7.2.3.20-B Capacities of PVC conduits

Maximum Capacities of steel conduits for the simultaneous drawing in of single core p.v.c cables or rubber cables

Cable Size			**Conduit Size and Gauge**			
Nominal Conductor Size mm^2	Number and diameter of wire No/mm^2	Nominal overall Diameter mm	16mm or 5/8 in	20mm or ¾ in	25mm or 1in	32mm or $1^{1/4}$ in
1	2	3	4	5	6	7
PVC cables			Metric A or B	Metric A or B	Metric A or B	Metric A or B
			Maximum number of cables			
1	1/1.12	2.9	7	12	20	34
1.5	1/1.38	3.1	6	11	18	30
1.5	7/0.50	3.3	6	10	16	28
2.5	7/1.78	3.5	5	8	14	20
2.5	7/0.67	3.8	4	7	12	20
4	7/0.85	4.3	3	5	9	15
6	7/1.04*	4.9	2	4	7	12
10	7/1.35	6.2	-	2	4	7
16	7/1.70	7.1	-	2	3	5
25	7/1.24	9	-	-	2	3

35	19/1.53	10.1	-	-	2	3
50	19/1.78	12	-	-	-	2
	Rubber cables					
1	1/1.13	3.4	5	9	15	25
1.5	1/1.38	3.6	5	8	13	22
2.5	1/1.78	4	4	6	10	18
4	7/0.85	5.2	2	4	6	10
6	7/1.04	6	-	3	4	8
10	7/1.35	7.3	-	2	3	5
16	7/1.70	8.4	-	-	2	4
25	7/2.14	10.1	-	-	-	2
35	19/1.53	11.7	-	-	-	2

NOTE: The maximum number of cables in the table relate to conduit runs incorporating not more than two 90^o bends equivalent. Where runs include additional bends, sets or other restrictions, the number must be appropriately reduced. This applies particularly where solid conductor cables are to be drawn.

7.3.2.19.8 The use of solid (non-inspection) conduit, elbows or tees shall be restricted to:
Locations at the ends of conduits immediately behind a light fitting outlet box or accessory of the inspection type; or

7.3.2.19.9 Ends of lengths of conduits shall be so reamed and where they terminate at boxes, trunking and accessories not fitted with spout entries, shall be so bushed, as to obviate abrasion of cables.

7.3.2.19.10 Substantial boxes of ample capacity shall be provided at every junction involving a cable connection in a conduit system. Where non-metallic conduits are used, and where metal conduits are terminated, boxes may be of non-absorbent, non-flammable material other than metal. All unused conduit entries shall be blanked off, and all removable covers firmly secured to provide complete enclosure.

7.3.2.19.11 Conduit systems not intended to be gas-tight shall be self-ventilating, and drainage outlets shall be provided at any points in the installation where condensed moisture might otherwise collect.

7.3.2.20 Metal Conduit: Special Requirements

7.3.2.20.1 Metal conduits and fittings for use in wiring systems shall comply with NIS Specifications for rigid steel conduits and fittings; for flexible steel conduits and adaptors and for aluminum or zinc-base-alloy conduits and fittings as appropriate. Where steel pipes are used as conduits, they shall comply with appropriate NIS specifications and shall have a corrosion-resistant finish inside and outside.

7.3.2.20.2 Metal conduits systems shall be earthed. All joints shall be made mechanically and electrically continuous by screwing or by substantial mechanical clamps, or by inserts but plain slip or pin-grip sockets shall not be used.

7.3.2.20.3 For the purposes of these Standards, flexible steel conduits having an outer sheath of insulation material (e.g. PVC) shall be deemed to be metal conduits.

7.3.2.20.4 Cables of a. c. circuit installed in steel conduit shall always be so bunched that the cable of all phases and the neutral conductor (if any) are contained in the same conduit.

7.3.2.21 Non-metal Conduit: Special Requirements

7.3.2.21.1 Rigid non-metallic conductors and fittings for use there-with shall comply with relevant NIS specifications as appropriate.

7.3.2.21.2 Non-metallic systems shall be used only where it is ensured that they are suitable for the extremes of ambient temperatures to which they are likely to be subjected to in service, and where used, earth continuity conductor shall be installed throughout the system.

7.3.2.21.3 The method of support for rigid PVC conduit shall allow for the longitudinal expansion and contraction of the conduits that may occur with variation of temperature under normal operating conditions.

7.3.2.21.4 For the purposes of these Standards, conduits comprising metal parts having an inner and outer covering of insulating materials are deemed to be non-metallic conduits, provided that effective precautions are taken to prevent the metal parts of the conduits at their ends from coming into contact with any other metal parts.

7.3.2.21.5 Flexible metal conduit and fittings shall comply in all respects with NIS NIS IEC 61386-1. Flexible non-metallic conduit shall comply with NIS NIS IEC 61386-1 and fittings for use therewith shall also comply with the NIS NIS IEC 61386-25.

7.3.2.21.6 Flexible metal conduit shall not be used as the sole means of providing earth-continuity, and earth-continuity conductor complying with the requirements of NIS specifications shall be provided for every part of a system formed by such conduit. Where necessary, flexible conduit shall be adequately supported.

7.3.2.22 Pre-fabricated, Duct and Trunking Systems

7.3.2.22.1 In the prefabrication of conduit systems that are not to be wired in-situ, adequate allowance shall be made for variations in building dimensions so that the conduits or cables are not subjected to tension or other strain during installation. Adequate precautions shall also be taken against damage to such systems during installation and any subsequent building operations, especially against deformation of the conduits and damage to any exposed cable ends.

7.3.2.22.2 Ducts of metal or insulating material, and trunking, shall be securely fixed, and where they are liable to mechanical damage they shall be adequately protected.

7.3.2.22.3 Trunking shall be constructed of metal or non-combustible insulating material.

7.3.2.22.4 Cables of a.c. circuits installed in steel ducts or trunking shall always be so bunched that the cables of all phases and the neutral conductor (if any) are contained in the same duct or trunking.

7.3.2.22.5 Every entry to finished ducts or trunking shall be so placed as to prevent the ingress of water, or be protected against such ingress. All removable covers shall be securely fixed after wiring is completed.

7.3.2.22.6 Every outlet for cables from a duct system, every joint in such a system, and every joint between such a system and another type of duct or conduit, shall be so formed that the joints are mechanically sound and that the cables drawn in are not likely to suffer abrasion.

7.3.2.22.7 Every bend formed in a concrete duct (whether or not formed by channels or formers retained in position after the concrete has set) shall be of an inner radius not less than four times the diameter of the completed duct

7.3.2.22.8 Ducts cast in-situ in concrete, by means of a suitable formwork laid before the concrete is poured, into which cables are to be drawn (whether or not the former is retained in position after the concrete has set) shall be so formed that the radial thickness of concrete or screed surrounding the cross-section of the completed duct is not less than 15mm at every point. Where all or any part of the completed duct is formed by the concrete or the screed rubber-insulated, braided and compound cables, non-sheathed PVC-insulated cables are installed in this type of duct and there is a risk that the duct may become damp, the cable shall be of a type having overall extruded covering of PVC.

7.3.2.22.9 The number of cables to be installed in ducts shall as will permit easy drawing-in without damage to the cables and shall be such that a space factor of 35% is not exceeded. This space factor relates to runs of ducts incorporating not more than two 900 bends or the equivalent; for runs having more bends than this, appropriate reduction shall be made in the number of cables installed.

7.3.2.22.10 The number of cables to be installed in trunking or channels shall be such that a space factor of 45% is not exceeded.

7.3.2.23 Flexible Cords and Cables: Special Requirements

7.3.2.23.1 Flexible cables or flexible cords shall be used for all connections to movable apparatus. For the purposes of this provision, an electric cooker of rated input exceeding 3kW is deemed not to be movable.

7.3.2.23.2 Where armoured flexible cables and flexible cords are used, the armouring shall not be used as the sole means of providing earth continuity conductor, an additional earth continuity conductor shall be provided.

7.3.2.23.3 Flexible cables and flexible cords shall not be used as fixed wiring unless contained in earthed metal or other non-combustible and mechanically strong enclosure. This requirement shall not apply to short lengths of sheathed flexible cable or flexible cord used for final connections to fixed apparatus or connection of control gear of fluorescent lamps or discharge lamps. Non-sheathed flexible cables and flexible cords shall not be drawn into conduits or ducts.

7.3.2.23.4 Exposed lengths of flexible cables or flexible cord used for final connections to fixed apparatus shall be as short as possible and connected to the fixed wiring by one of the following means:

a. a plug and socket-outlet;

b. a fused spur-box having suitable provision for the entry of the flexible cable or flexible cord;

c. a switch forming the means of local control of the apparatus; or

d. a suitable joint box.

7.3.2.23.5 Where a twin flexible cord supports, or partly supports, a light fitting, the maximum mass supported by the cord shall not exceed the appropriate value indicated in table 7.2.3.23.5.

Table 7.2.3.23.5

Nominal cross-sectional area of conductor mm^2	Maximum mass (kg)
0.75	3
1.0	5

7.3.2.23.6 No flexible extension shall be taken more than 2m across a ceiling to a droplight. An insulated hook fixed to the ceiling shall support such flexible extensions.

7.3.2.24 Consumers Wiring Between Buildings

7.3.2.24.1 Consumer's wiring intended for operation at low voltage and installed underground for distribution between a building and point of utilization not attached thereto (e.g. another building), shall be in the form of one or more of the following systems, using the types of cable indicated in Clauses 7.2.3.25.1.1 to 7.2.3.25.1.3.

7.3.2.24.2 **In ducts:**

a. Metal-sheathed and served cable;
b. Mineral-insulated, metal-sheathed cable having an overall extruded covering of PVC, preferably black in colour;
c. Armoured PVC insulated cable having an overall extruded covering of PVC; or
d. PVC insulated, PVC sheathed cable or rubber-insulated cable having an ORFR and HRFR sheath.

7.3.2.24.3 **In conduits or pipes:**

a. PVC insulated, PVC sheathed cable, or rubber-insulated cable having an ORFR or HRFR sheath in adequately protected heavy-gauge steel conduit or galvanized steel pipe, provided that the conduit or pipe shall not be used as an earth-continuity conductor, or
b. PVC insulated sheathed cable or rubber-insulated cable having an ORFR or HRFR sheath in non-metallic conduit.

7.3.2.24.4 **Laid Direct in the Ground**

a. Metal-sheathed, armoured and served underground cable;
b. Armoured p.v.c. insulated cable having overall extruded covering of PVC; or
c. Metal-sheathed and served underground cable or mineral insulated copper-sheathed cable having an overall extruded covering of PVC with mechanical protection by cable cover except where installed under a permanent surface.

7.3.2.24.5 Consumer's wiring intended for operation at low voltage and installed on exterior surface walls, boundary walls and the like for distribution between a building and a point of utilization not attached thereto (e.g. another building), shall be in the form of one or more of the following systems:

a. Heavy-gauge hot-dipped galvanized steel conduit (see Appendix 2) or steel pipe systems complying with Clauses 7.2.3.21.1. - 7.2.3.21.4;
b. Mineral-insulated, metal-sheathed cable, preferably having an overall covering of PVC preferably black in colour;
c. Armoured and served cables or preferably, armoured cables having an overall covering of PVC or an ORFR or HRFR sheathed overall preferably black in colour;
d. Lead-sheathed cables; and
e. Insulating cables having a PVC sheath preferably black in colour, or high impact rigid PVC conduit, preferably black in colour provided such wiring shall not be installed on fences.

7.3.2.24.6 Consumer's overhead wiring intended for operation at low voltage and for distribution between a building and a point of utilization not attached thereto (e.g. another building), shall be in the form of one or more of the following systems using the types of cable or conductor indicated. Lengths of span shall not exceed, and heights above ground shall not be less than, the appropriate values indicated in Table 7.2.3.24.3

Table 7.2.3.24.3

Maximum lengths of span and minimum heights above ground for consumers' overhead wiring between buildings etc

Types Of System, And Relevant Item Of Standard 7.2.3.25.5	Maximum Length Of Span (m)	Minimum Height Of Span Above Ground		
		At Road Crossing (m)	In Position Accessible To Vehicular Traffic Other Than Road Crossings (m)	In Positions Inaccessible To Vehicular Traffic (m)
Cables sheathed with PVC or having an ORFR and flame-retardant or HRFR sheath, without intermediate support (item (i))	3			3.5
Cables sheathed with PVC or having an ORFR or HRFR sheath, in heavy-gauge steel conducts (item (ii))	3			3
PVC covered overhead line conductors insulators without intermediate support (item (iii))	30	5.8 (for all types)	5.2 (for all types)	3.5
Cables sheathed with or having an ORFR and HRFR sheath supported by a centenary wire (item (iv))	No limit			3.5
Aerial cable incorporating A catenary wire (item (v))	No limit subject to Regulation 7.3 (x)			3.5
Bare or PVC covered Overhead lines installed in accordance with the over head line Regulations (item (vi))	No limit			5.2

a. PVC insulated, PVC sheathed cable, or rubber-insulated cable having an ORFR or HRFR sheath, preferable black in colour, without intermediate support; provided that the terminal supports shall be so arranged that no undue strain is placed upon the conductors or insulation of the cable, and provided that adequate precautions are taken against any risk of chafing of the cable sheath;
b. PVC insulated, PVC sheathed cable, or rubber-insulated cable having an ORFR and HRFR sheath, installed in heavy-gauge hot-dipped galvanized steel conduit without intermediate support; provided that the conduit shall be earthed in accordance with the earthing standard and shall be securely fixed at the ends of the span. It shall not be jointed in its span;
c. PVC covered (bundled or separated) overhead line conductors of hard-drawn copper, hard-drawn cadmium copper, hard-aluminum, steel cored aluminum, aluminum alloy, installed on insulators without intermediate support; provided that no part of the span shall be accessible to any person from any building or other place without the use of a ladder or other special device;
d. Cables having a sheath of PVC or lead, or an ORFR or HRFR sheathed preferably supported by a catenary wire;
e. Special aerial cable incorporating a catenary wire; and

f. Bare or PVC covered overhead lines having conductors of hard-drawn copper, hard-drawn cadmium copper, hard-aluminium or steel-cored aluminium or aluminium alloy.

7.3.2.25 Electric Bells, Telephone and Signaling Devices

7.3.2.25.1 Cables which are used in connection with electric bells, telephone and signaling devices, and other similar devices, in a building shall be kept away from or not be installed in the same casing or conduit as the cables used for distribution of the electrical supply throughout the building.

7.3.2.25.2 Bell and signaling circuits (except telephone circuits,) may be operated from the electric lighting, heating, or power supply mains, provided that they are connected to the secondary side of double-wound transformers, having a secondary voltage of twelve volts, and further provided that:

a. Each transformer is protected on the primary side by a single-pole switch and fuse, and one side of the secondary winding is earthed;
b. The conductors, when un-enclosed are secured individually by means of insulated tapes, and where subject to mechanical injury they are adequately protected;
c. Joints in the conductors are, as far as practicable, avoided, but where they are unavoidable they shall be staggered, soldered and efficiently insulated; and
d. The conductors are insulated with vulcanized rubber/PVC save that ordinary bell-wire may be used if the transformers are of a capacity not exceeding 50 (fifty) Watts and so designed that on sustained short circuit their impedance is such as to limit the current to such a value as will not burn out the transformer.

7.3.2.25.3 The control-circuit wiring and accessories in wiring systems having extra-low voltage control shall comply with the following requirements:

a. Remote controlled switches shall have their live parts enclosed in non-combustible and non-absorbent cases. They shall be fixed in full view in readily accessible positions. The insulation resistance between the supply terminals and the control terminals of the switch shall not be less than 100 Mega ohms;
b. All control wiring shall be run entirely separate from the supply wiring;
c. The voltage of the control circuit shall not exceed twenty-four (24) volts. Transformers shall be double-wound with one side of the secondary earthed and shall be securely mounted, accessible and be controlled by a switch and fuse on the primary side;
d. Where subject to mechanical injury conductors shall be protected. When un-enclosed they shall be secured with clips having rounded edges or insulated staples. But two or more conductors shall not be secured under the same staple;
e. Between roof and ceiling, conductors may be fastened to the sides of joists or battens-without further protection. Where buried in plaster or concrete they shall be enclosed in an approved metallic sheathing. All joints shall be accessible, and be efficiently soldered and insulated;
f. Push Buttons shall be of substantial mechanical strength. The conductors shall terminate in suitable terminals and be secured by a metal thread screw. Heating/ air-conditioning circuits shall not be controlled by this system unless fitted with an

indicating/temperature-sensing device.

7.3.2.26 Hazardous Locations

7.3.2.26.1 Electric wires, fittings, consuming devices, electrical storage batteries, and associated equipment installed in hazardous locations in which explosive or highly inflammable substances are produced, manufactured, refined, stored or packed shall be installed and maintained to comply with the following additional requirements:

a. All electrical conductors shall be enclosed in an efficiently earthed metallic envelope so constructed that in the event of the ignition of an inflammable or explosive material within the metallic envelope, there will be no transmission of flame to the atmosphere surrounding it;
b. Each consuming device shall be provided with automatic protective equipment to cut off the electricity in the event of overload or an electrical fault developing, in addition to means for normally cutting off all power to, or, in the immediate vicinity of the device in the event of danger. This paragraph shall not apply to single light which forms part of a group of lights installed and maintained in conformity with this provision;
c. All current consuming devices including lighting fixtures shall be housed in metallic enclosures certified as flame-proof and shall meet the NIS NIS IEC 60079 Standards for such devices and maintained in such a condition that the validity of the flame-proof quality is not compromised;
d. The attachment of all metallic envelopes enclosing cables to consuming devices shall be such as not to invalidate any flame-proof certificate;
e. Before effecting maintenance or repairs involving the opening of a flame-proof enclosure, all conductors within the flame-proof enclosure to be worked on shall be made dead and earthed; and upon completion of maintenance or repair, the apparatus shall not be energized until all openings have been closed to restore its flame-proof status;

7.3.2.26.2 In this standard “certified as flame-proof” means to comply with the NIS IEC 60079-0. The Commissioner, ESS shall be notified in writing in any particular case to approve an alternative certification as being an adequate substitute for the requirements of this provision.

7.3.2.26.3 In rooms containing stationary electric storage batteries of the lead-acid or alkaline types, or where corrosive gases or liquids which are not explosive or highly inflammable are present, the following shall apply:

a. The system of wiring employed shall be such that all electrical conductors including earthing connections are enveloped in a corrosion-proof non-metallic sheath;
b. Where metallic enclosures are necessary used for motors, switch-gear or other accessories, including conductors which are liable to mechanical damage, all exposed metallic surfaces shall be effectively painted or otherwise coated to resist corrosion;
c. All cable entries and accessories shall be such that the non-corrosion sheath of

conductors enters the terminal chamber of the equipment accessory and the entry hole or holes are fitted with an accessory to exclude the corrosive liquid or gas present; and

d. All unused entry holes shall be effectively sealed.

7.3.2.26.4 In freezing or cooling environments, the following shall be adhered to:

a. Distribution boards shall not be fixed in freezing or cooling chambers;
b. Switches shall not be fixed in freezing or cooling chambers;
c. No conductors other than those required for the supply and use of current therein shall be installed in freezing chambers and cold stores;

7.3.2.26.5 In hot environment, the following shall be adhered to:

a. Cable insulated with rubber shall not be used in situations where the temperature of the conductor would exceed 60ºC for short periods, or 50ºC for long periods;
b. Cable insulated with paper or fibre shall not be used in situations where the temperature of the conductor would exceed 80ºC;
c. Cables used shall comply with the appropriate temperature class as specified by the manufacturer for the environment in which they are to be installed;
d. Where higher temperatures are likely to be experienced, the wiring shall be in accordance with the requirements of the NIS NIS IEC 60079.

7.3.2.26.6 All cables shall be installed in such a manner as will not damage or weaken the building unnecessarily and with the least possible cutting-away of any structural work.

7.3.3 Utilization and Restriction of Bare Conductors for Indoor Wiring

7.3.3.1 Utilization of Bare Conductors

a. Bare or lightly insulated conductors may be installed in building for the following purposes only:Earth continuity conductors, earthing leads;
b. The external conductors of earthed concentric wiring systems;
c. Conductors of extra-low voltage systems;
d. Protected rising-main and bus-bar systems;
e. Collector wires for travelling cranes or trolleys or for similar purposes.

7.3.3.1.1 Bare or lightly insulated conductors of extra-low voltage systems shall have adequate insulators, and further protection where necessary, to ensure that they do not pose risk of fire.

7.3.3.1.2 Where bare conductors are used for rising-main and bus-bar systems operating at low voltage, they shall:

a. Be so installed that they are inaccessible to unauthorised persons and either be totally enclosed in earthed metal or fixed in a channel, trunking, or shaft specifically provided for the purpose;
b. Be of adequate strength to withstand the electro-mechanical forces that may be set up by prospective short-circuit current;
c. Be free to expand and contract, as the temperature changes, without detriment to themselves or to any other part of the installation; and
d. Where they pass through floors, walls, partitions, or ceilings, they shall pass through

directly and be protected by enclosure in non-absorbent, non-combustible insulating material, unless earth metal trunking is used.

7.3.3.1.3 Bare conductor wires of the type described in Clause 7.2.4.1.1(e) that are necessarily exposed in normal service shall be efficiently protected against accidental contact by screens or barriers or by adequate clearance. At each strain position for such wires, suitable straining gear fitted with double insulators shall be provided.

7.3.3.2 Collector and Trolley Cables

7.3.3.2.1 Bare conductors may be used as collector or trolley wires for travelling cranes and similar appliances and for battery connections. The conductors shall be supported upon insulators, and so spaced that risk of accidental contact between the conductors themselves or between conductors and walls or any other conducting structure is reduced to a minimum.

7.3.3.2.2 The circuit supplying current to such bare conductors shall, except in the case of the regulating cells of batteries, be protected either by a suitable circuit breaker or by a suitable switch and fuse.

7.3.3.2.3 Bare conductors extended to positions liable to lightning-discharge shall be fitted with lightning-arrestors on each pole or phase.

7.3.3.2.4 Wall rosettes or brackets used as supports for span-wires shall not be fixed within 300mm of any gas-pipe.

7.3.3.3 Restriction on the Use of Bare Conductors

Except as specified in Clauses 7.2.4.1 and 7.2.4.2 above, bare conductors shall be used only in positions not ordinarily accessible to unauthorized persons and in such circumstances as may be approved by NERC.

7.3.4 Electrical Conductors Used for Indoor Wiring

Conductors used for indoor wiring shall have their respective current carrying capacities not less than the maximum current demands of the circuit in which they shall be used and be capable of withstanding their prospective fault current and suitable for operation in the environment at the design voltage of the installation.

7.3.4.1 Selections and Sizes of Conductor Cables

7.3.4.1.1 Factors to be considered in sizing of cables shall be:

a. Conductor material;
b. Insulating material;
c. Ambient temperature;
d. Method of installation;
e. Effect of thermal insulating material;
f. Allowable maximum voltage drop from the origin of the circuit to the load.

7.3.4.1.2 The low-voltage indoor wiring shall be annealed copper wire of cross sectional area not less than 1.5 mm^2 or other equally sized wire which may be of superior quality.

7.3.4.1.3 For Category I circuits as provided in Clause 7.2.3.13, live conductors shall have a cross-sectional area of:

a. Not less than 1.5 mm^2 for surface wiring using PVC insulated PVC sheath copper cables;
b. Not less than 1.5 mm^2 for single core PVC insulated copper cables installed in conduit, duct, or trunking;
c. Not less than 16 mm^2 for aluminium conductors;
d. Not less than 0.75 mm^2 for flexible cables and flexible cords.

7.3.4.2 Protection by Electrical Insulation

7.3.4.2.1 Live conductors shall be completely covered with insulation which:

a. Can withstand the mechanical, electrical, thermal and chemical stresses to which it may be subjected in service; and
b. Can only be removed by destruction.

7.3.4.3 Electrical Insulation Testing

Where insulation is applied during the erection of the installation, the quality of the insulation shall be verified by tests equivalent to those specified in the applicable NIS 358 for similar type-tested equipment. Non-impregnated paper, asbestos, fabric, wood or pressed hemp shall not be used for insulating purposes. Where insulating tapes are permitted to be used in low voltage installations, they shall have a minimum thickness of 0.21 mm. Voltage Grading of Cables for Low Voltage Applications

(a) PVC insulated non-sheathed cables manufactured to NIS NIS IEC 60227 shall be 450/750V grade.
(b) PVC insulated, PVC sheathed cables up to 35 mm^2 manufactured to NIS NIS IEC 60227 shall be 300/500V grade. For cables greater than 50 mm^2 manufactured to NIS IEC 60227, voltage grade shall be 600/1000V.
(c) PVC insulated, PVC sheathed armoured cables of any size manufactured to NIS NIS IEC 60502 shall be 600/1000V grade.
(d) XLPE insulated, non-sheathed or PVC sheathed cables manufactured to NIS NIS IEC 60502 shall be 450/750V grade and to NIS NIS IEC 60502 shall be 600/1000V grade.
(e) XLPE insulated, PVC sheathed armoured cables manufactured to NIS NIS IEC 60502 shall be 600/1000V grade.

7.3.5 Allowable Current of Indoor Wirings

The allowable current of PVC-insulated conductor and XLPE-insulated conductor used for low-voltage indoor wiring shall conform to the following conditions~~:~~

7.3.5.1 Allowable Current and Current Reduction Factor Of Insulated Conductors

The allowable current of the conductors given in Table 77.2.6.1(a) is the value in this table multiplied by the allowable current correction factor (a) for ambient temperatures of 30°C or less or by the current reduction factor calculated by the formula (b) (θ denotes ambient temperature) of current reduction factor for ambient temperatures exceeding 30°C according to the insulator materials given in Table 7.2.6.1(b).

Table 7.2.6.1(a): Allowable current of indoor wiring

Conductor		Allowable current (A)		
Twisted conductor (nominal sectional area, mm^2)	Single wire (diameter, mm)	Annealed or hard-drawn copper wire	Hard-drawn aluminum wire	Aluminum alloy wire
	1.0 or more and less than 1.2	16	12	12
	1.2 or more and less than 1.6	19	15	14
	1.6 or more and less than 2.0	27	21	19
	2.0 or more and less than 2.6	35	27	25
	2.6 or more and less than 3.2	48	37	35
	3.2 or more and less than 4.0	62	48	45
	4.0 or more and less than 5.0	81	63	58
	5.0	107	83	77
0.9 or more and less than 1.25		17	13	12
1.25 or more and less than 2		19	15	14
2 or more and less than 3.5		27	21	19
3.5 or more and less than 5.5		37	29	27
5.5 or more and less than 8		49	38	35
8 or more and less than 14		61	48	44
14 or more and less than 22		88	69	63
22 or more and less than 30		115	90	83
33 or more and less than 38		139	108	100
38 or more and less than 50		162	126	117
50 or more and less than 60		190	148	137
60 or more and less than 80		217	169	156
80 or more and less than 100		257	200	185
100 or more and less than 125		298	232	215
125 or more and less than 150		344	268	248
150 or more and less than 200		395	308	284
200 or more and less than 250		469	366	338
250 or more and less than 325		556	434	400
325 or more and less than 400		650	507	468
400 or more and less than 500		745	581	536
500 or more and less than 600		842	657	606
600 or more and less than 800		930	745	690
800 or more and less than 1000		1,080	875	820
1000		1,260	1,040	980

Table 77.2.6.1(b) Current reduction factor

Insulator material	Allowable current correct ion factor (a)	Formula (b) of current reductio n factor

PVC (excluding heat-resistant polymers)	1.00	$\sqrt{\dfrac{60-\theta}{30}}$
XLPE (limited to cross-linked polymers)	1.41	$\sqrt{\dfrac{90-\theta}{30}}$

7.3.5.2 Allowable Current When Put in a Conduit

If the insulated conductors in Paragraph 1 are placed in a synthetic resin raceway, synthetic resin tube, metallic raceway, metallic tube or flexible conduit for use, the allowable current of that conductor shall be the allowable current prescribed in Paragraph 1 multiplied by the current reduction factor (c) in Table 7.2.6.2

Table 7.2.6.2: Current reduction factor when put in conduit

Number of electrical conductors in one conduit	Current reduction factor (c)
3 or less	0.70
4 or less	0.63
5 or 6	0.56
7 or over and 15 or less	0.49
16 or over and 40 or less	0.43
41 or over and 60 or less	0.39
61 or over	0.34

7.3.6 Indoor Wiring Works

7.3.6.1 Work Methods and Their Applications

The work methods of low-voltage indoor wiring include the 13 types given in the following items, i.e., synthetic resin tube work, metallic tube work, flexible conduit work, cable work, insulator work, synthetic resin raceway work, metallic raceway work, metallic duct work, bus duct work, floor duct work, cellular duct work, lighting duct work and flat protective layer work, and they shall be applied according to the division of places of installation and operation voltages as shown in Table 7.2.7.1.

Table 7.2.7.1: Application of low-voltage indoor wiring work

Operation voltage / Place of installation / Kind of work	300 V or less						Greater than 300 V					
	Open place		Accessible concealed place		Inaccessible concealed place		Open place		Accessible concealed place		Inaccessible concealed place	
	Dry place	Other places	Dry place	Other places	Dry place	Other places	Dry place	Other places	Dry place	Other places	Dry place	Other places
Synthetic resin tube work	○	○	○	○	○	○	○	○	○	○	○	○
Metallic tube work	○	○	○	○	○	○	○	○	○	○	○	○
Flexible conduit work	○	○	○	○	○	○	○	○	○	○	○	○

Cable work	○	○	○	○	○	○	○	○	○	○	○	○
Insulator work	○	○	○	○			○	○	○	○		
Synthetic resin raceway work	○		○									
Metallic raceway work	○		○									
Metallic duct work	○		○				○		○			
Bus duct work	○	○	○				○		○			
Floor duct work					○							
Cellular duct work					○							
Lighting duct work	○		○									
Flat protective layer work			○									

The mark ○ indicates a place where the work concerned can be executed.

7.3.6.2 *Execution Methods of Various Types of Work*

The execution methods of the various types of work in 7.2.7.1 shall conform to Table 7.2.7.2.

Table 7.2.7.2

Electrical conductors, earthing work and installation methods of low-voltage indoor wiring

Kind of Work	Electrical conductor	Earthing work	Installation method
Synthetic resin tube work	Insulated and stranded wire (excluding the case of 3.2 mm or less)	-	Connection of electrical conductors is not allowed in the tube Tube supporting clearance shall be 1.5 m or less
Metallic tube work	Insulated and stranded wire (excluding the case of 3.2 mm or less)	Earthing work Class D shall be applied to tubes for 300 V or less and Class C for more than 300 V (*2)	Connection of electrical conductors is not allowed in the tube Tube and accessories shall be made of brass or copper Tube wall thickness shall be 1.2 mm or over for embedment in concrete and 1 mm or over for others
Flexible conduit work	Insulated and stranded wire (excluding the case of 3.2 mm or less)	Earthing work Class D shall be applied to tubes for 300 V or less and Class C for more than 300 V (*2)	Connection of electrical conductors is not allowed in the tube Tube and accessories shall be made of metal
Cable work	Cable	Earthing work Class D shall be applied to the metallic parts of protective devices that accommodate electrical conductors for 300 V or less, and Class C for more than 300 V.	Wire supporting clearance shall be 2 m or less (if laid down along the bottom or side of a building part) and 6 m or less (if laid down vertically in an inaccessible place) Provide an appropriate protective device for electrical conductor installed in a place subject to the pressure of heavy objects or severe mechanical impact.
Insulator work	Insulated conductor (excluding PVC-insulated conductor) (*1)	-	Exclude easy access for 300 V or less. Exclude access for more than 300 V. Connection of electrical conductors is 6 cm or over Clearance from electrical conductor to building part shall be 2.5 cm or over for 300 V or less and 4.5 cm or over for more than 300 V (2.5 cm or over in a dry place). Supporting clearance shall be 2 m or less (for wire laid down along the top or a side of a building part). 6 m or less, however, for voltages exceeding 300 V and electrical conductor laid down otherwise.
Synthetic resin raceway	Insulated conductor (excluding PVC-insulated conductor)	-	Connection of electrical conductors is not allowed in the raceway

work			
Metallic raceway work	Insulated conductor (excluding PVC-insulated conductor)	Earthing work Classs D shall be applied to the raceway.	Connection of electrical conductors is not allowed in the tube Tube and accessories shall be made of brass or copper
Metallic duct work	Insulated conductor	Earthing work Class D shall be applied to ducts for 300 V or less and Class C for more than 300 V.	Connection of electrical conductors is not allowed in the duct The sum of the sectional area of wires laid down in a duct shall be 20% or less of the inner sectional area of the duct Duct shall be more than 5 cm in width and 1.2 mm or over in wall thickness made of iron plate galvanized or coated with enamel or the like Duct supporting clearance shall be 3 m or less
Bus duct work	Bus duct	Earthing work Class D shall be applied to ducts for 300 V or less and Class C for more than 300 V (*2).	Duct supporting clearance shall be 3 m or less if attached to a building part In a humid place, use a duct for outdoor use and see that no water collects inside.
Floor duct work	Insulated and stranded wire (excluding the case of 3.2 mm or less)	Earthing work Class D shall be applied to the duct.	Connection of electrical conductors is not allowed in the duct (wire branching is excluded if that branch is easily accessible.) Duct shall be 2 mm or over in wall thickness made of steel plate galvanized or coated with enamel or the like
Cellular duct work	Insulated and stranded wire (excluding the case of 3.2 mm or less)	Earthing work Class D shall be applied to the duct.	Connection of electrical conductors is not allowed in the duct (wire branching is excluded if that branch is easily accessible.)
Lighting duct work	Lighting duct	Earthing work Class D shall be applied to the duct (excluding ducts 4 m or less in length).	Duct supporting clearance shall be 2 m or less Do not install a duct through a building part.
Flat protective layer work	Flat conductor-synthetic resin insulated conductor	Earthing work Class D shall be applied to the upper protective layer, upper installed protective layer, joint box, and metallic case of an insertion connector.	Used on a branch circuit protected by an overcurrent circuit breaker of 30 A or less Line-to-earth voltage of the circuit shall be 300 V or less Install a leakage circuit breaker on the power supply circuit.

*(*1) Use bare conductor if Clause7.2.4.3 is complied with.*

*(*2) Apply earthing work Class D if 300 V is exceeded and there is no danger of a person's touching the duct.*

7.3.7 Installation of Mains for Electrical Circuits

In installing the low-voltage indoor mains from the service entrance switch or the switchboard in the receiving room to the branching point of a branch circuit, the following condition shall be complied with:

The mains shall be installed in a place free of danger of damage and an electrical conductor with an allowable current equal to or greater than the value given below shall be used for the mains.

7.3.7.1 Installation of Overcurrent Circuit Breakers

On the power supply side of the mains, an overcurrent circuit breaker to protect such mains shall be installed on each pole except the neutral wire according to the following items:

a. If motors and the like are not connected to the overcurrent circuit breakers:

An overcurrent circuit breaker having a rated current equal to or less than the allowable current of the mains shall be installed.

b. If motors and similar household appliances that require a large starting current the like are connected to the overcurrent circuit breakers:
An overcurrent circuit breaker having a rated current equal to or less than the value 3 times the total of rated current of the motors similar household appliances that require a large starting current and the like to which the total of rated current of other household appliances is added shall be installed.
However, it shall not exceed 2.5 times the allowable current of the mains.

c. Exceptions to installation of overcurrent circuit breakers:
Installation of an overcurrent circuit breaker may be omitted in the following cases:

i. The case where the allowable current of the mains is 55% or more (*2) of the rated current of an overcurrent circuit breaker that protects other mains connected to the power supply side of the mains concerned
*(*2) If the length of such mains is 8 m or less, the rated current shall be 35% or more.*

ii. The case of which length of mains is 3 m or less and to which no other mains are connected on the load side

7.3.8 Installation of Branch Circuits

A low-voltage indoor circuit branching off from low-voltage indoor mains and reaching household electric appliance shall be installed according to the following conditions:

7.3.8.1 Installation of switching devices and overcurrent circuit breakers

For a branch circuit, a switching device and overcurrent circuit breaker shall be installed on each pole (see*) at a place within 3 m from the branching point on the mains.

If the allowable current of the electrical conductor from the branching point to the switching device and overcurrent circuit breaker is 55% or more (see**) of the rated current of the overcurrent circuit breaker that protects the mains connecting to that electrical conductor, the switching device and overcurrent circuit breaker may be installed at a place beyond 3 m from the branching point.

**For the overcurrent circuit breaker, the neutral pole is to be excluded.*

***If the length of electrical conductor from the branching point to the switching device and overcurrent circuit breaker is 8 m or less, it shall be 35% or more.*

7.3.8.2 Installation of Branch Circuits

The branch circuits are divided into the following 3 classes according to the load types connected to them.

7.3.8.2.1 Branch circuit supplying electricity to lighting load equipment with a rated current exceeding 50 A

A branch circuit supplying electricity to one household electric appliance, other than a motor, with a rated current exceeding 50 A shall be installed as follows:

a. No other load than this household electric appliance shall be connected to this branch circuit.
b. The rated current of the overcurrent circuit breaker shall not exceed the value 1.3 times the rated current of that household electric appliance (See***).

****If that value does not fit any standard rating of overcurrent circuit breakers, employ the nearest larger rating.*

c. The allowable current of the electrical conductor shall be equal to or greater than the rated current of that household electric appliance and the overcurrent circuit breaker according to (b) above.

7.3.8.2.2 **Branch Circuit Supplying Electricity to an Electric Motor Alone**

A branch circuit supplying electricity to an electric motor alone shall be installed as follows:

a. The rated current of the overcurrent circuit breaker shall be 2.5 times the allowable current of the electrical conductor connecting to that overcurrent circuit breaker (See****).

*****If the rated current of that electrical conductor exceeds 100 A and the said rated current value does not fit any standard rating of overcurrent circuit breakers, employ the nearest rating larger than that value.*

b. For each portion of the low-voltage indoor wiring, the allowable value of the electrical conductor of that portion shall be equal to or greater than the value 1.25 times (See*5) the total of rated current of the electric motors supplied from that portion of the low-voltage indoor wiring.

*(*5)If the total of the rated current of the electric motors concerned exceeds 50 A, the allowable current shall be equal to or greater than 1.1 times that current.*

7.3.8.2.3 **Other branch circuits**

For branch circuits other than those described in Clause 7.2.9.2.2(a) and 7.2.9.2.2(b) above, the capacity of the electrical conductor, receptacle, screw connector and socket connected to such branch circuit shall be as shown in 7.2.9.2.2 according to the magnitude of the rated current of the overcurrent circuit breaker that protects the branch circuit.

As to thickness of electrical conductor, annealed copper wire of the thickness shown in Table 7.2.9.2.2 or other wire of equal or larger rated current shall be used.

Table 7.2.9.2.2

Installation / Type of low-voltage indoor circuit	Thickness of low-voltage indoor wiring	Thickness of electrical conductor in the portion (limited to 3 m or less) from a screw connector, socket or receptacle to its branching point	Receptacle to which to connect	Screw connector or socket to which to connect
Circuit protected by an overcurrent circuit breaker with a rated current of 15 A or less	Diameter 1.6 mm	-	Receptacle with a rated current of 15 A or less	Socket of the screw type with a nominal diameter of 39 mm or less, or a socket other than the screw type, or screw connector with a nominal diameter of 39 mm or less
Circuit protected by an overcurrent circuit breaker with a rated current of greater than 15 A and 20 A or less			Receptacle with a rated current of 20 A or less	
Circuit protected by an overcurrent circuit breaker (excluding a distributing circuit breaker) with a rated current of greater than 15 A and 20 A or less	Diameter 2 mm	Diameter 1.6 mm	Excluding a receptacle to which a plug with a rated current of less than 20 A can be connected	Socket for halogen lamps, or a socket for incandescent lamps other than halogen lamps or for mercury lamps, with a nominal diameter of 39 mm, or a screw connector with a nominal diameter of 39 mm
Circuit protected by an overcurrent circuit breaker with a rated current of greater than 20 A and 30 A or less	Diameter 2.6 mm		Receptacle with a rated current of 20 A or over and 30 A or less	
Circuit protected by an overcurrent circuit breaker with a rated current of greater than 30 A and 40 A or less	Sectional area 8 mm^2	Diameter 2 mm	Receptacle with a rated current of greater than 30 A and 40 A or less	
Circuit protected by an overcurrent circuit breaker with a rated current of greater than 40 A and 50 A or less	Sectional area 14 mm^2	Diameter 2 mm	Receptacle with a rated current of greater than 40 A and 50 A or less	

7.3.9 Switching Devices at the Indoor Main Lines

7.3.9.1 General Installation

7.3.9.1.1 A switching device shall be installed on the low-voltage indoor circuit in a place near the service entrance and it shall be easy to open and close.

7.3.9.1.2 An installation shall be provided with a main switch or circuit breaker and a means of isolation to cut off all voltages. These two functions may be incorporated in a single device. The main switch or circuit breaker should interrupt all live conductors (i.e. phase and neutral conductors) and be capable of cutting off the full load current of the installation from supply. For a 3-phase 4-wire a.c. supply, a linked switch or linked circuit breaker may be arranged to disconnect the phase conductors only and in such case, a link should be inserted in the neutral conductor and securely fixed by bolts or screws.

7.3.9.1.3 For an installation serving more than one building, the installation inside separate buildings shall be treated as a separate installation, and a separate main switch or circuit breaker and a separate means of isolation for each building are required as in Clause 7.2.10.1.2

7.3.9.1.4 Every circuit or group of circuits shall be provided with a means of:

a. Isolation; and

b. Interrupting the supply on load under abnormal conditions.

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

7.3.9.1.6 Under no circumstances shall a means of isolation or a switching device be provided in a protective circuit.

7.3.9.1.7 A circuit breaker used to receive supply direct from the electricity distribution company's transformer. An isolator may be used in conjunction with a fixed type circuit breaker provided that it is mechanically interlocked with the circuit breaker.

7.3.9.2 Appliances, Equipment or Luminaire

All appliances, equipment or luminaire used by consumers shall comply with the standards and specifications prescribed by applicable NIS standards. In addition, energy efficient lamps for lighting systems and electrical appliances shall be preferred.

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

7.3.9.2.2 For electric discharge lighting installations operating normally at an open-circuit voltage exceeding low voltage, an effective local means for isolation of the circuit from supply (such means being additional to the switch normally used for controlling the circuit) shall be provided for the isolation of every self-contained luminaire, or of every circuit supplying luminaires at a voltage exceeding low voltage.

7.3.9.2.3 An installation where it is necessary for a person or persons to enter or work in close proximity with normally unguarded moving parts which may constitute a hazard shall be provided with a means of isolation near the moving parts in addition to any emergency switching provided.

7.3.9.3 Emergency Switching

7.3.9.3.1 Means shall be provided for emergency switching using a self latching push button such that any part of the installation where it may be deemed necessary to control supply so as to remove an unexpected danger, thereby keeping the installation isolated until the push button is unlatched.

7.3.9.3.2 Means for emergency switching shall be provided for the purpose of cutting off the appropriate supply to the circuit concerned as rapidly as possible in order to obviate or to remove a dangerous condition as soon as it becomes apparent. A typical example where means for emergency switching shall be provided is a machine driven by electrical means which may give rise to danger.

7.3.9.3.3 Where electrically powered equipment is operated within the scope of NIS NIS IEC 60204, the requirements for emergency switching of that standard apply.

7.3.10 Control of Supply to User Site Installation

The following types of installations are covered by this standard:

a. Domestic/Residential
b. Commercial
c. Industrial
d. Specialized Installations (military, telecommunications, infrastructure, mobile, construction sites, temporary installations, mining)
e. Others

7.3.10.1 Supply Control

7.3.10.1.1 Supply to every User Site installation shall be adequately controlled by Switchgear readily accessible to the consumer which shall incorporate means of:

a. Isolation from sources of supply;
b. Excess-current protection; and
c. Earth-leakage protection.

7.3.10.1.2 All such installations shall be easily accessible to the consumer and as near as possible to:

a. The point or points of entry of the service mains in the case of a public supply;
b. The generator in the case of private plant; or
c. The inverter unit, in the case of renewable energy and fossil fuel energy sources.

7.3.10.1.3 In the case of a private plant where the building containing the generator is isolated from the building in which the electricity is consumed, a main switch shall be installed at a point at which the main cables enter the latter building. Where more than one building is supplied from common mains, switches shall also be installed at each building.

7.3.10.1.4 The means of isolation required by Clause 7.2.11.1.1 shall comprise a linked switch suitable for operation on load or a linked circuit-breaker arranged to disconnect all supply having an excess-current release fitted in each live conductor of the supply.

7.3.10.2 Supply Protection

7.3.10.2.1 The means of excess-current protection required by Clause 7.2.11.1.1 shall comprise either a suitably rated fuse in each live conductor of supply or circuit-breaker having an excess-current release fitted in each live conductor of the supply.

7.3.10.2.2 Every means of excess-current protection shall be suitable for the maximum short-circuit current attainable.

7.3.10.2.3 The characteristics and settings of excess-current protective gear, including fuses and arrangement of the installation, shall be such that discrimination in the operation of the excess-current protection gear is ensured.

7.3.10.2.4 Throughout a 2-wire installation connected to a source of supply having one pole connected with earth, all fuses and single-pole control devices, e.g. switch or circuit-breakers, thermostats and the like, shall be connected in the live conductor only. This does not preclude the use of double-pole linked devices controlling both conductors of the supply.

7.3.10.2.5 Throughout a 2-wire installation connected to a source of a supply having neither pole connected with earth, every switch or circuit-breaker shall be of the double-pole linked type, and fuses (where installed) shall be fitted in both poles.

7.3.10.2.6 Every conductor in the installation shall be protected against excess current by a fuse or circuit breaker fitted at the origin of the circuit of which the conductor forms a part. The current rating of every fuse used for this purpose shall not exceed that of the lowest-rated conductor in the circuit protected, account being taken of the class of excess-current protection afforded by the fuse. Every circuit breaker used for this purpose shall operate when the circuit protected is subjected to a sustained excess current of 1.5 times the rating (appropriate to this form of protection) of the lowest-rated conductor in the circuit. Sizes of fuse elements for semi-enclosed fuses are given in Table 7.2.11.2.6.

Table 7.2.11.2.6

Sizes of fuse elements composed of plain or tinned copper wire, for use in semi-enclosed fuse

Current rate of fuse (A)	***Nominal diameter of wire (mm)***
3	*0.15*
5	*0.2*
10	*0.35*
15	*0.5*
20	*0.6*
25	*0.75*
30	*0.85*
45	*1.25*
60	*1.53*
80	*1.8*
100	*2*

7.3.10.3 Cut-Out Fuses

7.3.10.3.1 For low and medium voltage cut-out shall comply with Clause 7.2.11.1.1

7.3.10.3.2 The cut out fuse shall be provided with a suitable incombustible and insulating carrier for the fuse of such shape as to protect a person handing it from shock and burns; and contacts shall be provided on the carrier to which the ends of the fuse can be readily attached.

7.3.10.3.3 The cut out fuse base shall be provided with fixed circuit contacts of such shape as to retain the carrier in position in the presence of vibration.

7.3.10.3.4 The bus bars, fixed contacts, removable contacts, and fuses shall be so shielded as to protect a person against contact with live metal parts when the fuse-carrier is being inserted or removed.

7.3.10.4 Consumers Switchboard

7.3.10.4.1 Switchboards shall be constructed wholly of durable, non-ignitable, non-absorbent materials in accordance with NIS NIS IEC 60439, and all insulation shall be of permanently high strength of not less than 100MΩ.

7.3.10.4.2 All switchboards with metallic frames shall be provided with suitable terminals, to which the earthing lead shall be attached.

7.3.10.4.3 The various exposed live parts of switchboards shall be so arranged by suitable spacing or shielding with non-ignitable insulating materials that an arc cannot be maintained between any such parts or between such parts and earth. For voltage not exceeding 250 volts the minimum clearance between the live metal parts of fuses of opposite polarity or phase, or between any live metal and any earthed metal shall be 50 mm. Fuses which on blowing expel the gas parallel to the axis of the fuse, and which are of opposite polarity or phase, may be mounted one above the other if an insulating shield is fixed between them.

7.3.10.4.4 The arrangements of all parts shall be such that the connections to all instruments and apparatus can be readily traced.

7.3.10.4.5 All parts, including connections, shall be readily accessible; and no fuse, circuit-breaker, or switch other than an isolating switch shall be fixed on the back of the switchboard panel if it is necessary to operate the same from behind.

7.3.10.4.6 All nuts or parts carrying over 25A shall be effectively locked so that they cannot become loose.

7.3.10.4.7 All bus bars and connections on switchboards shall be in accordance with relevant NIS NIS IEC 61439-1.

7.3.10.4.8 Where a scheme of colouring is employed to distinguish switchboard busbars and connections to individual poles or phases, such scheme of colouring shall be in accordance with relevant NIS.

7.3.10.4.9 The arrangement of bus bars carrying alternating currents shall be in accordance with relevant NIS NIS IEC 60947.

7.3.10.4.10 Conductors must be symmetrically placed and spaced apart, and so arranged that the course of every conductor may be readily traced.

7.3.10.4.11 All circuits, instruments, and important apparatus shall be clearly and indelibly labelled for identification.

7.3.10.4.12 Switches shall be so arranged that their blades or moving parts are disconnected from the supply in the off position. They shall be so mounted that the top of the handle is at a height not exceeding 2.3m above floor level.

7.3.10.4.13 In every case in which the switches and fuses are fitted on the same pole or phase these switches shall preferably be so arranged that the fuses are disconnected from the supply when their respective switches are in the “off” position.

7.3.10.4.14 Where meters, service fuses or other apparatus belonging to the electricity distribution company are to be mounted on a switchboard, loops shall be left in the leads of sufficient length to allow the ends of the conductors to be properly connected by the electricity distribution company.

7.3.10.4.15 Each distribution board shall have fitted in or on its case or cover, or in an adjacent conspicuous position, an indication of the circuit protected by each fuse or circuit-breaker contained therein and of the appropriate current rating for the circuit so protected.

7.3.10.4.16 Where service meters are not mounted on the main switchboard they shall be mounted on a substantial base.

7.3.10.4.17 Where instrument transformers are used, and are easily accessible, all live metal parts shall be effectively insulated.

7.3.10.5 Final Sub-Circuits

7.3.10.5.1 The number of points which may be supplied by a final sub-circuit of rating not exceeding 15 amperes is limited by their aggregate demand as determined from Table 7.2.11.5.1. There shall be no other allowance for diversity in the final sub-circuit and the current rating of the cable must not be exceeded.

Table 7.2.11.5.1

Assumed current demand of points and other apparatus

Points or other Apparatus	Current demand to be assumed
(a) 15-amps socket-outlet	15 amperes
(b) 13-amps socket-outlet	13 amperes
(c) 5-amps socket-outlet	5 amperes
(d) Lighting-outlet	Current equivalent to the connected load, with a minimum of 100 watts per lamp-holder.
(e) Electric clock, electric shaver supply unit, shaver socket outlet, bell transformer, and current-using apparatus of a rating not greater than 15 volt-amperes.	May be neglected
(f) All other stationary appliances	Nominal current.

*Note **1**: In the interest of good planning it is undesirable that whole of the fixed lighting of an installation should be supplied from one final sub-circuit.*

*Note **2**: In the interest of providing the consumer with an adequate installation it is recommended that use should be made of ring final sub-circuits where applicable.*

7.3.10.5.2 All socket outlets in any one room shall be connected to the same phase (or pole of a 3-wire system).

7.3.10.5.3 Not more than one phase supply shall be brought into a multi-gang switch box.

7.3.10.5.4 Where an installation comprises more than one final sub-circuit, each shall be connected to a separate way in a distribution board.

7.3.10.5.5 The wiring of each final sub-circuit shall be electrically separated from that of every other final sub-circuit. To facilitate disconnection of each sub-circuit for testing, the neutral conductors shall be connected at the distribution board in the same order as that in which the live conductors are connected to the fuses or circuit-breakers.

7.3.10.5.6 A final sub-circuit having a rating exceeding 15 amperes shall not supply more than one point. For the purpose of this Clause, the following items may each be regarded as one point –

a. A cooker control unit incorporating socket outlet;
b. A light fitting track system provided that individual light fittings are suitably protected against excess current;
c. A packaged air-conditioner unit
d. Submersible pump

7.3.10.5.7 To determine the rating of a final sub-circuit supplying stationary cookers in domestic premises, the current demand of each cooker shall be assessed to be not less than 30A. The minimum size of cable should be 6 mm^2.

7.3.10.5.8 Every stationary cooking appliance in domestic premises shall be controlled by a switch separate from the appliance and installed within 2m of the appliance.

7.3.10.6 Diversity for Consumer Final Sub-Circuit

7.3.10.6.1 Diversity shall not be allowed for when calculating the size of circuit conductors and switchgear and circuits other than final sub-circuits, to the extent specifically permitted by NIS IEC standards for cooking appliances.

7.3.10.6.2 Diversity may be allowed for when calculating the size of circuit conductors and switchgears and circuits other than final sub-circuits provided this is justified by known or anticipated conditions.

Note*: Allowance for diversity is a matter calling for special knowledge and experience. The application of diversity shall be decided by the engineer responsible for designing each particular installation.*

7.3.10.7 Ring and Radial Circuits

7.3.10.7.1 In domestic installations either radial or ring final sub-circuit conforming with Table 7.2.11.7.2 may be installed to serve socket outlets complying with the relevant NIS Specification and Stationary appliances of rating not exceeding 13A provided that the general requirements of this Standard and in case of ring sub-circuits, the special requirements of Clauses 7.2.11.7.5 to 7.2.11.7.11 are met.

7.3.10.7.2 Each socket outlet of a twin or multiple socket outlet units shall be counted as one socket for the purposes of Clause 7.2.11.7.1 and Table 7.2.11.7.2

Table 7.2.11.7.2

Radial and ring final sub-circuits

Description and special condition if any		***Minimum copper conductor size or rubber or p.v.c. insulated cable used throughout.***	***Minimum copper clad aluminum conductor size of p.v.c. insulated cable used throughout***	***Minimum copper conductor size of mineral insulated cable used throughout (alternative to Col.2)***	***Rating of fuse or circuit-breaker protecting final sub-circuits.***	***Maximum number of socket –outlets and stationary appliance of rating not exceeding 13 amperes.***
1		2 mm^2	3 mm^2	4 mm^2	5 A	6
(a)	Radial final sub circuit serving one room only of less than $30m^2$ floor area which is not a kitchen………………..	2.5	4	1.5	20	Provided that no fixed water heating appliance shall be connected to any of these points.
(b)	Radial final sub circuit, serving rooms other than in (a) above……….	2.5	4	1.5	20	2
(c)	Ring final sub circuit, with spurs if any………………….	4.0	6	2.5	30	6
	Other	2.5	4	1.5	30	See 7.2.11.7.8 -12

Appliance of 15VA rating or less may be ignored.

7.3.10.7.3 A stationary appliance connected permanently (i.e. not through a plug and socket outlet) to a radial or ring final sub-circuit conforming with Clause 7.2.11.7.1 shall be locally protected by a fuse of rating not exceeding 13A and controlled by a switch or protected by a circuit-breaker of rating not exceeding 15A.

7.3.10.7.4 The conductor sizes tabulated in Table 7.2.11.7.2 are minimum values and shall be increased if necessary where circuits are installed in groups or in conditions of high ambient temperature, taking account of the class of excess-current protection provided. In such circumstances it must be ensured that –

a. for radial final sub-circuits, the current rating of the conductors is not less than that of the fuse or circuit-breaker protecting the final sub-circuit, and
b. for ring final sub-circuits, the current rating of the conductors forming the ring is not less than 0.67 times the rating of the fuse or circuit breaker protecting the final sub-circuit.

7.3.10.7.5 Each circuit conductor of a ring final sub-circuit shall be run in the form of a ring, commencing from a way in a distribution board (or its equivalent), looping into the terminals of socket outlets and joint boxes (if any) connected in the ring and returning to same way of the distribution board.

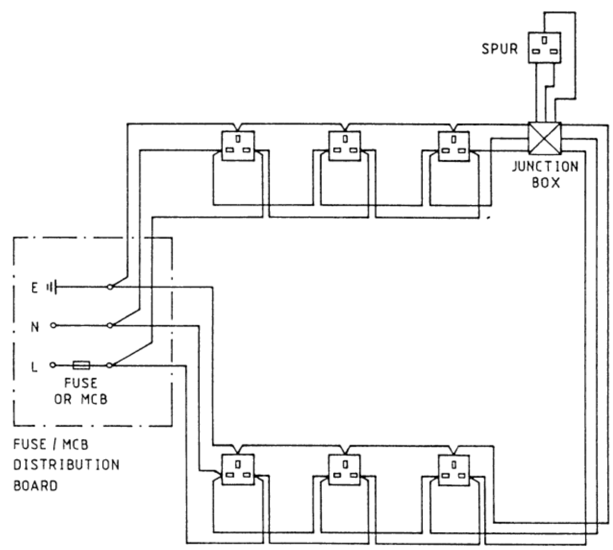

Fig 7.2.11.7.5: Arrangement of conductors in ring circuit connection

7.3.10.7.6 Except where a ring final sub-circuit is run throughout in metallic conduit, ducts or trunking, or in metal-sheathed cable, the earth-continuity conductor shall also be run in form of a ring having both ends connected to earth at the distribution board (or its equivalent).

7.3.10.7.7 Each ring final sub-circuit conductor shall be looped into every socket-outlet or joint box which forms parts of the ring and shall either remain unbroken throughout its length or, alternatively, if the conductor is cut, its electrical continuity shall be ensured by joints.

7.3.10.7.8 For ring final sub-circuits complying with Clauses 7.2.3.44.1 to 7.2.3.44.4 the total number of spurs shall not exceed the total number of socket-outlets and stationary appliances-connected directly in the ring.

7.3.10.7.9 For ring final sub-circuits complying with Clauses 7.2.11.7.1 to 7.2.11.7.4, the total number of spurs shall be connected through fused spur boxes. The rating of the fuse shall not exceed that of the cable forming the spur and in any event shall not exceed 13A. The total current demand of points served by a fused spur shall not exceed 13A.

7.3.10.7.10 For ring final sub-circuits complying with Clauses 7.2.11.7.1 to 7.2.11.7.4 non-fused spurs shall be connected to the ring at the terminals of socket-outlets or at joint boxes or at the origin of the ring in the distribution board. Non-fused spurs shall have a current rating not less than that of the conductors forming the ring. Not more than two socket-outlets, or one twin socket-outlet, or one stationary appliance, shall be fed from each non-fused spur.

7.3.10.7.11 In domestic premises, a ring final sub-circuit may serve an unlimited number of points but shall not serve more than one room. Where two or more ring final sub-circuits are installed, the socket-outlets and stationary appliance to be served shall be reasonably distributed among the separate final ring sub-circuits.

7.3.10.7.12 For industrial, commercial and other non-domestic installations radial and ring final sub-circuits not conforming to the requirements of Clauses 7.2.11.7.1 to 7.2.11.7.10 may be installed where, owing to diversity, the maximum demand of apparatus to be connected is estimated not to exceed the corresponding fuse or circuit-breaker ratings set out in Table 7.2.11.7.2.

7.3.10.7.13 Provision shall be made so that every portable appliance and portable light fitting can be fed from an adjacent, conveniently accessible socket outlet.

Note 1*: For industrial and commercial premises, it may be desirable to provide pilot lamps to indicate when portable non-luminous heating appliances such as smoothing irons and soldering irons, are in operation*.

Note 2*: For hand-held appliances which are likely to be used out-door or in damp situations, attention is drawn to the added safety which can be obtained by the use of a double-wound transformer having a reduced secondary voltage or alternatively by the use of monitored earth-continuity circuits.*

Table 7.2.11.7.13

Radial and ring final sub-circuits

Description and special condition if any	*Minimum copper conductor size or rubber or p.v.c. insulated cable used throughout. (mm)*	*Minimum copper clad aluminum conductor size of p.v.c. insulated cable used throughout (mm)*	*Minimum copper conductor size of mineral insulated cable used throughout (alternative to Col.2) (mm)*	*Rating of fuse or circuit-breaker protecting final sub-circuits. (A)*	*Maximum number of socket –outlets and stationary appliance of rating not exceeding 13 amperes.*

(a)	Radial final sub circuit serving one room only of less than 30m² floor area which is not a kitchen………………..	2.5	4	1.5	20	Provided that no fixed water heating appliance shall be connected to any of these points.
(b)	Radial final sub circuit, serving rooms other than in (a) above………..	2.5	4	1.5	20	2
(c)	Ring final sub circuit, with spurs of	4.0	6	2.5	30	6
(d)	Any other……….	2.5	4	1.5	30	See Clause 7.2.11.7.1 to 7.2.11.7.12

7.3.10.8 Control of Socket Outlets and Appliances

7.3.10.8.1 All sockets used in low voltage circuit shall comply with the requirements of NIS NIS IEC 60884.

7.3.10.8.2 Where the supply is direct current, each socket-outlet shall be controlled by a switch immediately adjacent thereto or combined therewith. Where the supply is alternating current and the plug is readily withdrawable, such a switch need not be provided.

7.3.10.8.3 An appliance or light fitting connection to an installation other than by means of a plug and socket outlet shall be controlled by a switch or switches which shall be arranged to disconnect all live supply conductors. For an appliance fitted with heating elements which can be touched or into which more than one phase of the supply is introduced, the switch shall be a linked switch arranged to break all the circuit conductors.

7.3.10.8.4 The switch required by Clause 7.2.11.8.3 shall be separate from the appliance or light fittings in a readily accessible position subject to the provisions of Clauses 7.2.11.8.5, 7.2.11.8.6 and 7.2.11.8.7 where applicable

7.3.10.8.5 The switch required by Clause 7.2.11.8.3 may be mounted on the appliance or light fittings provided the connections are so arranged that the appliance or light fittings can be dismantled for maintenance without exposing any parts which remain live. Where live cables/parts are exposed, they shall be as short as possible, separated from any other conductors or cables by screens of earthed metal or suitable barriers of insulating material and so installed that they are not adversely affected by any heat from the appliance or light fittings.

7.3.10.8.6 Where Clause 7.3.3.16 requires a switch to be situated so as to be normally inaccessible to a person who is using a bath or shower, it is admissible for the switch to be placed in a suitable position outside and immediately adjacent to the normal access door of the room, or to be of the type operated by an insulating cord.

7.3.10.8.7 The switch or switches providing control of comprehensive space cooling, or light installations, comprising more than one appliance or light fitting may be installed in a separate room.

7.3.10.9 Electric Motor Circuits

7.3.10.9.1 Every electric motor shall be provided with means for starting and stopping, the latter so placed as to be easily operated by the person in charge of the motor.

7.3.10.9.2 Every electric motor shall be provided with the control apparatus specified in the following:

a. Means to prevent automatic restarting after a stoppage due to a drop in voltage or failure of supply.
b. Where more than one method of manually stopping a motor is provided and danger might be caused by the unexpected restarting of the motor, or of a machine being driven by the motor, means to prevent restarting until every stopping device has been reset.
c. Means of isolation suitably placed and so connected that all voltages may thereby be cut off from the motor and all apparatus including any automatic circuit breaker, used therewith. If this means of isolation is remote from a motor, an additional means of isolation adjacent to the motor shall be installed, or alternatively, provisions shall be made for the primary means of isolation to be locked in the "off" position.

7.3.10.9.3 Every electric motor having a rating exceeding 0.37kW shall be provided with control apparatus incorporating a suitable device affording protection against excess current in the motor or in the cables between the device and the motor. The local electricity distribution company shall be consulted regarding the installation of motors of rating exceeding 50kW, capable of drawing heavy starting current.

7.3.10.9.4

a. As a general guide, all motors shall be provided with control gears so that their starting currents at user's site installations do not exceed the limits given Table 7.2.11.9.4:

Table 7.2.11.9.4

Type of Supply	Motor Rating	Limit of Starting Current
Single Phase	Up to and including 0.75kW	Five times full load current
Single/three phase	Above 0.75kW and up to and including 5.6kW	Three times full load current
three phase	Above 5.6kW and up to and including 12kW	Twice full load current
three phase	Above 12 kW	One and a half times full load current.

b. Cables carrying the starting, accelerating and load current of a motor shall be of rating at least equal to the full-load current rating of the motor when rated in accordance with the relevant NIS requirements.
c. A final sub-circuit supplying a motor shall be protected in accordance with the requirements of Clause 7.2.11.2.1 unless Clause 7.2.11.9.4(d) applies.

d. Where a starter is provided which affords protection against excess current in a motor and in the cables between the starter and the motor, the rating of the fuse or circuit-breaker protecting the final sub-circuit which supplies the motor may be up to twice that of the cable between the fuse or circuit-breaker and the starter.
e. The sizes of the cables for motor circuits for slip ring or commutator induction motors shall be suitable for the starting and loading conditions. Insulated conductors installed shall be such that no stress can be applied by the conductors to any terminal to which they may be connected.
f. Fittings shall be so designed and fixed that neither dust not moisture can readily accumulate on live parts.
g. Where a hanging fitting exceeds 5kg in weight it shall be supported by a metal chain, tube, or rod, or by several flexible cords in such a manner that the maximum weight to which any cord is subjected shall not be greater than that specified in Clause 7.2.3.23.5.
h. Open-type fittings shall be furnished with inflammable shades unless such shades are kept free from contact with the lamps by suitable guards or supports.
i. Enclosed type fittings shall be provided with a removable glass receptacle arranged to enclose the lamp completely, and of such size or construction as to prevent undue heating of the lamp; and if the position of the fitting be such that the glass receptacle is liable to mechanical damage, the glass shall be protected by a suitable wire guard.
j. Fittings whether fixed or portable, shall, whenever exposed to rain, drip or externally condensed moisture, be of the weatherproof type.
k. Fittings for lamp shall be designed to provide for adequate dissipation of heat from such lamps.
l. Enclosed fittings shall be used at the following places:
   i. In places where inflammable or explosive dust or gas is liable to be present or where inflammable goods are stored, and they shall be of strong construction, having airtight external globes of thick glass provided with substantial guards.
   ii. In positions in which the lamp is either near to or can swing into contact with readily combustible materials.
m. The handle of every hand-lamp (not being a hand-lamp made entirely of metal specified in the last preceding standard) shall be made of treated hard-wood or of some suitable non-ignitable composite insulating material capable of withstanding all round usage in service.
n. Where portable fittings, appliances, or accessories are likely to be used, the voltage between any two points in one room or compartment shall not exceed 250 V unless:
   i. The fittings, appliances or accessories between which there may be a higher voltage are so situated that they cannot be brought within 2 meters of each other; or the metal frames and sheathing of all such portable appliances and accessories are earthed.
   ii. Flexible conductors of portable fittings or apparatus shall be connected through appropriately sized wall plugs.
   iii. Portable fittings shall be mounted on a base-block or a suitably fixed hook.

iv. Accessories other than fuses shall be mounted on a base-block unless they are completely enclosed in metallic casing, and where the surface on which it is mounted is liable to become damp the base-block shall be rendered impervious to moisture.

7.3.10.10 Ceiling Roses

7.3.10.10.1 A ceiling rose shall not be installed in any circuit operating a voltage normally exceeding 250 volts.

7.3.10.10.2 A ceiling rose shall be connected to the fixed wiring in such a manner that none of its terminals remains alive when the associated switch is off unless that terminal cannot be touched when the ceiling rose is dismantled to the extent necessary for the replacement of the associated flexible cord.

7.3.10.10.3 A ceiling rose shall not be used for the attachment of more than one outgoing flexible cord, unless it is specially designed for multiple pendants.

7.3.10.10.4 Non-flexible cable shall not be used for connection from the ceiling rose to any fitting or appliance.

7.3.10.10.5 The earthing terminal of every ceiling rose shall be connected to the earth-continuity conductor of the final sub-circuit.

7.3.10.11 Lamp-Holders

7.3.10.11.1 Lamp-holders for lamps shall normally be used only in circuits operating at a voltage not exceeding 250 volts.

7.3.10.11.2 Every lamp-holder for a bayonet-cap lamp in any damp situation or in any situation in which it can readily be touched by a person in contact with or standing on earthed metal shall be–

i. Earthed, or
ii. Constructed of, or shrouded in, insulating material and for moulded insulated bayonet, fitted with a protective shield.

7.3.10.11.3 Where bayonet or Edison screw lamp-holders are connected to a source of supply having an earthed neutral conductor, the outer or screwed contact shall be connected to that conductor. Where such lamp-holders are used in circuits having neither pole connected with earth, or in any damp situation in which they can readily be touched by a person in contact with or standing on earthed metal, they shall be provided with a protective shield of insulating material or shall be placed or safe guarded, so that neither the lamp cap nor the outer or screwed contact of the lamp-holder can be inadvertently touched when the lamp cap is engaged with that contact.

7.3.10.11.4 Where arc lamps are used in positions where danger might otherwise arise, they shall be protected either by a metal reflector rigidly fixed beneath the arc or by a globe or lantern. Wherever noxious fumes are likely to be emitted from such a lamp, suitable ventilation shall be provided.

7.3.10.12 Application of Transformers

7.3.10.12.1 Where a step-up transformer forms part of a consumer’s installation, a linked switch shall be provided for isolating the transformer from all circuit conductors of the supply.

7.3.10.12.2 An auto-transformer having an output in the extra-low-voltage range shall not be used to supply–

i. Any socket-outlet, or
ii. Any portable appliance, unless the auto-transformer is contained therein, or
iii. Earthed concentric wiring, or

7.3.10.12.3 A step-up autotransformer shall not be connected to an installation obtaining its supply from a system in which none of the poles of the supply is connected to earth.

7.3.10.12.4 The common terminal of every autotransformer winding shall be connected to the neutral conductor.

7.3.10.13 Capacitor

7.3.10.13.1 Every capacitor, unless incorporated for the sole purpose of radio interference suppression or directly connected across a motor winding, shall be provided with a means, such as a high-resistance leak, for its prompt automatic discharge immediately the supply is disconnected. This requirement shall not apply to small capacitors where no risk of shock can arise.

7.3.10.13.2 For Every user site supplied from L.T. and having connected load that includes induction motor(s) of 2.23 kW rating and above shall install low tension shunt capacitors of appropriate capacity across the terminals of such motors to improve average power factor to 0.85. Such capacitor(s) shall be maintained in working condition. The local electricity distribution company deserves the right to disconnect the user site if this Clause is infringed upon to ensure compliance only after which supply shall be restored.

7.3.10.14 Plugs, Socket-Outlets and Adaptors

7.3.10.14.1 Every plug and socket-outlet shall comply with the applicable requirements of NIS NIS IEC60884 and shall meet the provisions of 7.2.11.14(i) and 7.2.11.14 (ii) below.

i. It shall not be possible for any pin of the plug to be engaged with any live contact of its associated socket-outlet while any other pin of the plug is completely exposed; provided that this requirement shall not apply to socket-out-lets and plugs for extra-low voltage circuits, and
ii. It shall not be possible for any pin of the plug to be engaged with any live contact of any socket-outlet within the same installation other than the type of socket-outlet for which it is designed.

7.3.10.14.2 Any circuits for which one pole is earthed at the source of supply, every socket-outlet and plug shall be of the non-reversible type, with provisions for earthing.

7.3.10.14.3 Plug and socket-outlets may be used in two-wire circuits operating at a voltage not exceeding 250 volts for the connection of electric clocks, provided that the plug and socket-outlets are designed specifically for that purpose and that each plug incorporates a fuse of rating not exceeding 3A.

7.3.10.14.4 Every plug containing a fuse shall be non-reversible and so designed and arranged that no fuse can be connected in an earthed conductor.

7.3.10.14.5 For two-pole-and-earth circuits, the connection of plugs, socket-outlets and connectors shall be in accordance with Table 7.2.11.14.5.

TABLE 7.2.11.14.5

Connection of plugs, socket-outlets and connectors

	Corresponding conductor	
Terminal marking	***For circuits having an earthed neutral conductor***	***For circuits in which neither pole of the supply is earthed***
L N I or E	Live conductor Neutral conductor Earth-continuity conductor	Live conductors Earth-continuity conductor

7.3.10.14.6 Where outlets from a socket adaptor have a lower current rating than that of the input, appropriate fusing shall be provided for each outlet of lower rating. Every socket-outlet adaptor used at a voltage exceeding extra-low voltage shall be non-reversible and shall be so designed that the output contacts are arranged in the same phase or polarity as those of the corresponding socket-outlet. Adaptors intended for use with electric shavers shall incorporate a fuse of rating not exceeding 3A and shall be marked **"FOR SHAVERS ONLY"**

7.3.10.14.7 Weatherproof plugs and sockets shall be used whenever exposed to rain drops, or externally condensed moisture.

7.3.10.14.8 Such accessories shall be of especially robust construction, and be provided with efficient means to keep the sockets weatherproof when the plug is removed there from. When a loose cover is employed for this purpose it shall be anchored to the socket by means of a chain.

7.3.10.14.9 When the plug is inserted in its sockets, the combine fitting and its interlocking switch (if any), shall also be weatherproof.

7.3.10.14.10 In places where petrol-driven conveyances are stored or repaired, plugs and sockets shall be placed not less than 2 meters above the floor level unless an interlocked plug and gas-tight switch is used.

7.3.10.14.11 Adaptors for use in lamp holders shall be constructed of tough, flame retardant, non-conducting, non-hygroscopic material other than hardwood.

7.3.10.14.12 Adaptors for use in screw holders shall be of one of the following types–

i. Combine adaptor with pull-out plug,

ii. Adaptor with a loose screw to prevent twisting of the flexible conductor.

TABLE 7.2.11.14.12

Plugs and socket-outlets for low-voltage circuits

Type of plug and socket-outlet	***Rating (amperes)***
Fused plugs and shuttered socket-outlets, 2-pole and earth for a.c	13[a] (with fuses rated at 3 and 13)
Plugs (fused or non-fused) and socket-outlets, 2-pole and earth	2, 5, 15, 30

Plugs (fused or non-fused) and socket-outlets, protected type, 2-pole with earthing contacts	5, 15, 30
Plugs and socket-outlets (theatre type)	15
Plugs and socket-outlets(industrial type)	16, 32, 63, 125

7.3.10.15 Cable Couplers and Connectors

7.3.10.15.1 Cable couplers and connectors shall be mechanically sound and electrically continuous and grounded using either metal which can be earthed or in non-combustible insulating material. Where the apparatus to be connected requires earthing, every cable coupler and connector shall have adequate provision for maintaining earth continuity. In all cases, the socket shall be connected to the source of supply.

7.3.10.16 Electric Signs

7.3.10.16.1 Every electric sign shall comply with the following requirements–

a. It shall be readily accessible for inspection and attention;
b. It shall be fireproof, or alternatively the wiring shall be independent, and shall be controlled by a fuse and switch on each live conductor. When more than one switch is required the switches shall be linked;
c. Where elaborate switching and flashing apparatus is installed, a special flame retardant enclosure shall be provided;
d. If fixed in the open air:
   i. It shall be weather-proof and lamp-holders shall be weather proof;
   ii. Only non-ignitable material shall be used in its construction, except for letters and designs, for which hardwood is permissible.

7.3.10.16.2 Where indoor lighting is designated for emergency purposes in such places as hospitals, entertainment venues, schools, industrial premises, hotels amongst others, such installations shall comply with NIS IEC 60079.

7.3.11 Appliances

7.3.11.1 Heating and Cooking Appliances

7.3.11.1.1 All heating and cooking appliances for installation in domestic premises shall comply with the applicable NIS NIS IEC 60335 Standard.

7.3.11.1.2 The junction between elements and switches or external connecting leads shall be effected without solder by connectors which shall be so placed that the temperature of no part of the switch or terminal connections can rise above 80OC.

7.3.11.1.3 When an appliance is connected using a cooker control unit or a plug-socket is fitted to its cable, it shall have a switch and a fuse on the live side, and be so mounted as to secure freedom from electrical hazard. This plug shall have a separate contact connected to earth and any portable apparatus used from this plug shall be earthed in accordance with the requirement of these Standards.

7.3.11.2 Protection and Control of Appliances

7.3.11.2.1 Appliances shall be protected by fuses on each live conductor

7.3.11.2.2 Appliances shall be controlled as a whole by a switch on each live conductor and such switch shall be mounted on the wall adjacent to and within easy reach of such appliance. If more than one switch is so used for any one appliance, all such switches shall be linked.

7.3.11.2.3 The wiring to fixed appliances shall be in fixed conduit connected mechanically and electrically to the metal frame of the appliance provided that flexible conduit may be used between the wall and the appliance and is connected mechanically to the fixed conduit and the metal frame of the appliance.

7.3.11.2.4 For the purpose of this standard a fixed appliance is one which is obviously intended by size, weight, and construction to be secured in a fixed position.

7.3.11.2.5 Heating and cooking appliances shall not be fixed near combustible materials unless the latter are suitably protected.

7.3.11.3 Heating Points

7.3.11.3.1 Heating points shall each be rated at not less than 1,000 Watts, and shall be controlled by a switch of not less than 8A capacity. For appliances over 1,800 Watts, the heating points shall, except in the case of a multi-earthed neutral system, be controlled by a double-pole switch.

7.3.11.3.2 The minimum size of conductor for any heating point shall be 2.5 mm^2

7.3.11.3.3 Switches for heating points shall be at a distance not less than 300 mm from any switch controlling lighting.

7.3.11.4 General Requirements for Boilers and Water Heaters-

7.3.11.4.1 Electrode boilers and electrode water-heaters shall be connected to a.c. systems only, and shall be installed in accordance with the general requirements of Clauses 7.2.12.4.1 to 7.2.12.4.2 and, according to the type of equipment connected, with the particular requirements of Clauses 7.2.12.5 and 7.2.12.6.

7.3.11.4.2 The supply to the heater or boiler shall be controlled by a circuit-breaker which shall–

i. be of the multiple linked type arranged to disconnect the supply from all electrodes simultaneously,
ii. incorporate excess-current protective devices in each conductor feeding an electrode, and
iii. be so placed that the person in charge can easily operate it, and where it is not adjacent to the electrode boiler there shall be a means provided at the boiler for opening the circuit breaker instantaneously.

7.3.11.4.3 Adequate means, such as an isolator adjacent to the heater or boiler, or a locking device on the circuit breaker, shall be provided to prevent the apparatus from being energised while persons are working thereon.

7.3.11.4.4 Where the circuit-breaker is remote from the heater or boiler, indicating lamps shall be provided adjacent to or mounted on the boiler, to indicate whether the circuit-breaker is in the “on” or “off” position.

7.3.11.4.5 The earthing of the heater or boiler shall comply with the requirements for earthing in

Chapter 11, in addition, the shell of the heater or boiler shall be bonded to the metallic sheath and armour, if any, of the incoming supply cable. The rating of the earthing lead, which shall be connected to the shell of the heater or boiler, shall be not less than that of the largest phase conductor connected to the apparatus, or, where an earth-leakage protective device is provided, not less than the operating current of that device, subject to a minimum conductor size of 2.5 mm^2.

7.3.11.4.6 Where an electrode water-heater or electrode boiler is directly connected to a supply at a voltage exceeding low voltage, the installation shall, in addition to complying with the general requirements of Clauses 7.2.12.4.1 to 7.2.12.4.5 include a differential earth-leakage protective device arranged to disconnect the supply from the electrodes on the occurrence of a sustained earth-leakage current in excess of 10% of rated current of the heater or boiler under normal conditions of operation, except that if in any instance a higher value is essential to ensure stability of operation of the heater or boiler, the value may be increased to a maximum of 15%. A time delay may be incorporated in the device to prevent unnecessary operation in the event of unbalance of short duration.

7.3.11.5 Three-Phase Boilers and Water Heaters

7.3.11.5.1 Where an electrode water-heater or electrode boiler is connected to a three-phase supply, in addition to complying with the general requirements of Clauses 7.2.12.4.1 to 7.2.12.4.6, the shell of the heater or boiler shall be connected to the neutral of the supply as well as to the earthing lead. The current rating of the neutral conductor shall not be less than that of the largest phase conductor connected to the apparatus.

7.3.11.6 Single-Phase Boilers and Water Heaters

7.3.11.6.1 Single phase domestic thermal storage or instantaneous water heaters not exceeding 6 kW shall be connected to an individual final circuit and be controlled by a double-pole switch of adequate rating. If the water heater is installed in a bathroom, the double pole switch should be installed outside the bathroom in a convenient position.

7.3.11.6.2 A thermal storage or instantaneous water heater exceeding 30 A or having a current rating exceeding half of the maximum demand of an installation in any one phase, shall have a three-phase supply, except where approved by the electricity distribution company.

7.3.11.6.3 Every water heater or boiler having an un-insulated heating element immersed in the water shall comply with the requirements of Clause 7.2.12.6.4 to 7.2.12.6.8.

7.3.11.6.4 The parts of the heater or boiler intended to be connected to the incoming water supply and to the outlet pipe for the heated water, shall be of metal so as to afford the means of earthing required by these Standard.

7.3.11.6.5 The heater or boiler when in use shall have an insulation resistance between the element and the metal parts referred to in Clause 7.2.12.6.4 not less than 0.25 MΩ or a residual current of less than 1mA with water flowing.

7.3.11.6.6 The heater or boiler shall incorporate an automatic device to prevent an excessive rise in temperature.

7.3.11.6.7 All metal parts of the heater or boiler which are in contact with the water (other than current-carrying parts) shall be firmly connected to a metal water-pipe through which the water supply to the heater or boiler is provided, and the said water-pipe shall be in effective electrical connection with earth by a means independent of the earth-continuity conductor.

7.3.11.6.8 The heater or boiler shall be provided with an earthing terminal through which all exposed metal parts of the heater or boiler are connected and this terminal shall be connected to the earth-continuity conductor of the final sub circuit supplying the heater or boiler.

7.3.11.6.9 The heater or boiler shall be permanently connected to the electricity supply through a double-pole linked switch which is separate from and within easy reach of the heater or boiler, and the wiring from the heater or boiler shall be directly connected to that switch without the use of a plug and socket-outlet; and, where the heater or boiler is installed in a room containing a fixed bath, the switch shall in addition be placed outside the room.

7.3.12 Preventions of Interferences Caused By High Frequency Current, Voltage Flickers and Dips

All electrical appliances, equipment and luminaires capable of generating high frequencies shall be suppressed at their respective generating sources to mitigate interference with other vulnerable devices via conduction and radiation channels. In addition, equipment such as electric arc welding machines and arc furnaces shall be operated in accordance with NIS NIS IEC 60974-9 to minimize effects of voltage dips and flickers on other consumers.

7.3.12.1 Appliances Generating High Frequency Signals, Voltage Dips and Flickers

7.3.12.1.1 If the electrical appliance has the possibility of generating high frequency radio waves or radio frequency currents that might continuously and seriously interfere with the function of radio, television or other wireless devices, it shall be installed according to Clauses 7.2.13.1.2 and 7.2.13.1.3 to prevent such interference.

7.3.12.1.2 For fluorescent lamps, a suitably rated capacitor shall be provided in an appropriate place to suppress the interference in accordance with NIS NIS IEC 60081.

7.3.12.1.3 For a small AC series motor with an operation voltage in the low-voltage range and a rated output of 1 kW or less, one of the following shall be adhered to:

i. Capacitors 0.1 μF and 0.003 μF in capacitance values and of appropriate voltage rating shall be inserted respectively between motor terminals and between each motor terminal and the metallic case of the electrical appliance or the frame of the small AC series motor or the ground.

ii. For an electrical appliance containing a small AC series motor where the frame of the motor is insulated from the appliance's metallic case, steel stand and other accessible metallic parts, capacitors of 0.1 μF and 0.003 μF respectively shall be inserted between motor terminals and between each motor terminal and the motor frame or ground.

iii. A capacitor of 0.1 μF shall be inserted between each terminal of the AC series motor and ground.

iv. Where the AC series motor is inaccessible, capacitors of 0.1 μF and 0.003 μF respectively shall be inserted between electrical conductors that are connected to the electrical appliance at a place close to that appliance between each electrical conductor and the metallic case of the appliance or ground.

7.3.12.1.4 For a small AC series motor with an operating voltage in the low-voltage range and a rated output of 1 kW or less used for electric drills, a non-inductive capacitor 0.1 μF shall be inserted between motor terminals and through-type capacitor of 0.003 μF with sufficient shunting effect shall be inserted between each motor terminal and the ground.

7.3.12.1.5 For a neon lamp flasher, an appropriately designed filter shall be installed between power terminals and at a place close to each contact to prevent a radio-frequency current from occurring in the electrical circuit connected to the neon lamp flasher.

7.3.12.1.6 All LV installations where welding transformers are connected shall be required to install suitable capacitor(s) so as to ensure power factor of not less than 0.85 and reduce voltage dips and flickers to the barest minimum.

7.3.12.1.7 Electric arc welding sets having a current rating exceeding 25A single phase or 50% of the maximum demand of an installation in any one phase shall be permanently connected to the mains on a 3-phase supply. All exposed conductive parts of welding sets shall be effectively connected to earth.

7.3.12.1.8 All installations where arc furnaces of high capacities are connected shall require suitably rated Static Var Compensators (SVCs) to be sited at the points of common coupling so as to achieve power factor greater than 0.85 and minimize voltage fluctuations and flickering effects otherwise experienced by other consumers.

7.3.12.1.9 All appliances, luminaires and apparatus shall be designed, constructed and appropriately located so as to avoid interference and nuisance and shall exhibit maximum operational integrity and comply with EMC of NIS NIS IEC61000-3-11.

7.3.13 User's Site Protection and Over Current Circuit Breakers for Electric Motors

Every User's site shall be adequately protected against any mal-operation of installed appliances, equipment and failure of the wiring system. In addition, over current circuit breakers shall be provided at the user's site for electric motors.

7.3.13.1 User's Site Protection

7.3.13.1.1 The following devices shall be used as protective devices against overcurrent:

i. Miniature Circuit Breakers (MCB)
ii. Moulded Case Circuit Breakers (MCCB)
iii. High Breaking Capacity (HBC) Fuses
iv. Semi-enclosed Fuses
v. Circuit Breakers incorporating overcurrent release or in conjunction with fuses

7.3.13.1.2

a. Every electrical circuit and sub-circuit shall be protected against excess current by fuses, circuit breakers, or other similar devices which:
   i. Will operate automatically at current values which are suitably related to the safe current, ratings of the circuit, and
   ii. Are of adequate making and breaking capacity, and

iii. Are suitably located and of such construction as to prevent danger from over-heating, arcing or the scattering of hot metal when they come into operation and

iv. Permit ready renewal of fuse-elements without danger.

b. Where the earth-fault-leakage current from a circuit due to a fault of negligible impedance from a live conductor to earthed metal is sufficient to operate the fuses or circuit-breakers or other similar devices provided so as to comply with Clause 7.2.14.1.1, the current shall be protected against the persistence of earth-leakage currents liable to cause danger by suitably rated earth-leakage circuit-breaker (ELCB) or equivalent device.

c. No fuse, or circuit breaker other than a linked circuit breaker, shall be inserted in a conductor connected with earth, and any linked circuit breaker inserted in a conductor connected with earth shall be arranged to break also all the live conductors.

d. Every single-pole switch shall be inserted in the live conductor only, and any switch connected in the conductor connected with earth shall be a linked switch and shall be arranged to break also all the live conductors.

e. Overload protective and fault current protective devices shall be in accordance with the specifications of NIS NIS IEC 60947.

f. For devices providing protection against both overload current and fault current, they shall satisfy both the requirements of overload protective devices and fault current protective devices.

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

7.3.13.2 Overcurrent Circuit Breakers for Electric Motors

7.3.13.2.1 If an electric motor is installed indoors with a rated output exceeding 0.4 kW, an appropriate device shall be installed to automatically isolate, or alert the operator of an overcurrent that may damage the motor.

7.3.13.2.2 The overload protective device is not required to be installed provided:

a. the electric motor is installed at such a position where the operator can normally monitor it while it is in operation,

b. there is no danger of such an overcurrent being able to damage the motor stator winding, due to the loading condition of the motor,

c. the electric motor is an integral component of an appliance or equipment complying as a whole with an appropriate NIS.

7.3.13.3 Installation of Overcurrent and Fault Current Protective Devices

7.3.13.3.1 Overcurrent and fault current protective devices shall be installed in places at user's site readily accessible for maintenance.

7.3.13.3.2 Overload protective devices shall be so installed:

a. Where a reduction occurs in the value of current carrying capacity of the conductors of the installation.

b. At any point along the run of those conductors provided that the part of the run between the point where the value of current carrying capacity is reduced and the position of the protective device has no branch circuits or outlets for the connection of current using equipment.

7.3.13.3.3 Fault current protective devices, subject to Clause 7.2.14.3.1, shall be installed in such a manner as to reduce to the barest minimum the risk of fault, fire or danger to persons.

7.3.14 Indoor Electrical Equipment and Appliances

The term “indoor electrical equipment and appliances” refers to low-voltage incandescent lamps, fluorescent fittings, discharge lamps, household and business electric appliances installed indoors. These shall be installed according to the following standards:

7.3.14.1.1 All lamps or household appliances shall be installed so that no live part is exposed.

7.3.14.1.2 Installation of Fluorescent and Gas Discharge Lamps

a. Capacitors and chokes should normally be fitted inside the luminaire. Where they are fitted separately, they should be mounted in a metal box. Precautions should be taken to prevent the components from overheating, e.g. by the provision of adequate ventilation.
b. The type and size of cables should be properly selected with due regard to the ambient temperature, the inrush current and high voltages generated during starting. The neutral conductor in every discharge lamp circuit should have a cross-sectional area not less than that of the phase conductor.
c. Where fluorescent and gas discharge lamp are directly mounted on the ceiling care should be taken to ensure that the choke does not pose a fire risk.

7.3.14.2

Low-voltage business electrical appliances shall be installed so that the live parts are not exposed. This shall, however, not apply to electric furnaces, electric welders, electric motors and other appliances that are used with some live part inevitably exposed and in such cases where these are installed in a place made inaccessible for any person other than the operator.

7.3.14.3

A household or business electric appliance with live parts accessible to persons shall not be installed indoors.

7.3.14.4

If the indoor electric appliance is to be connected to an electrical conductor, the same shall be securely connected by means of screw fastening or similar means of fastening. In addition, no tension shall act on the connection point.

7.4 Special Installation

7.4.1 Traffic Signals

7.4.1.1 Wiring of Traffic Sign Lamp

The wiring to a traffic sign lamp shall be installed according to the following conditions:

a. The electrical conductor shall be of a PVC-insulated conductor equal or superior in strength and thickness to an annealed copper wire 1.5 mm^2 in diameter.
b. If the electrical conductor is a PVC-insulated conductor, it shall be suspended from a metallic wire with a tensile strength of 5 kN/m^2 or two or more stranded iron wires of 4 mm^2 in diameter or more.
c. For the metallic wire of Item (b) for electrical conductor suspension, an insulator shall be inserted at or near the supporting structures.

7.4.1.2 *Hanger Wire of Traffic Sign Lamp*

The hanger wire of a traffic sign lamp shall be installed according to the following conditions

a. The height of the electrical conductor shall be 2.5 m or more above the ground surface.

b. If the electrical conductor is to be installed by insulator work, the electrical conductor shall be bundled at appropriate intervals.

7.4.1.3

On the power supply side of the control device of a traffic signal lamp, a dedicated switching device and overcurrent circuit breaker shall be installed on each pole.

7.4.1.4

If the wiring of a traffic signal lamp circuit approaches or crosses a facility other than a building, road, pedestrian overpass, railroad, overhead telecommunication conductor, antenna or overhead electrical conductor, the clearance from the wiring of the traffic signal lamp circuit to such object shall be 60 cm or more. If the wiring of the traffic sign lamp is a cable, the clearance shall be 30 cm or more.

7.4.2 Public Street lamps

If an incandescent lamp, fluorescent lamp, mercury lamp or the like with a line-to-earth voltage of 230 V or less is to be installed on a supporting structure of a power distribution line, it shall be installed according to the following conditions:

7.4.2.1 *Approval for Installation of a Public Street lamps*

If a public street lamp is to be installed on a supporting structure owned by a power utility company, approval shall be obtained from the owner.

7.4.2.2 *Lighting Fittings of Public Street lamps*

a. No light fitting shall be fitted with accessories for signboards or ornamental purposes.

b. The light fitting shall be strong and durable and shall be attached to a pole firmly.

c. The light fitting shall be rated IP 66 in accordance with NIS IEC 60529.

d. The light fitting shall have a structure that allows for easy replacement of the lamps and other replaceable components.

e. The live conductor of the light fitting shall have a sectional area of 1.5 mm^2 or more.

f. The light fitting attaching band and attaching accessory hardware shall be made of steel plate given an anticorrosive treatment of galvanizing or stainless steel, which allows for easy attachment and detachment.

7.4.2.3 Installation of Apparatus

a. The attaching height of the apparatus shall be 4 m or more from the ground surface to the lowest part of the light fitting. The horizontal jutting distance shall be within 1 m from the point of attachment of the apparatus to the pole.

b. The Luminaries for road and street lighting system shall be in accordance with NIS IEC 60598-2-3.

7.4.2.4 Installation of Daylight Sensors

Automatic daylight sensor not built in the lighting control panel shall be installed at a place where it is not influenced by ambient light.

7.4.3 Swimming Pools and Fountains Installation

These requirements apply to the basins of swimming pools, fountains, paddling pools and their surrounding zones where, in normal use, the risk of electric shock is increased by a reduction in body resistance and contact of the body with earth potential. Swimming pools and fountains installations shall comply with the requirements of NIS NIS IEC 60364-7-702.

***Note**: Additional requirements may be necessary for swimming pools for medical purposes.*

7.4.4 Other Installations

7.4.4.1.1 Special locations (which include public places, parks, garden, sporting areas, illumination of monuments and flood lights) shall be installed in accordance with NIS IEC 60364-7-714.

7.4.4.1.2 Electrical installation in ships shall be in accordance with NIS IEC 60092-306.

7.4.4.1.3 Bath and shower electrical installation shall be in accordance with NIS IEC60364-7-701

7.4.4.1.4 Construction and demolition site installations shall be in accordance with NIS IEC60364-7-704.

7.4.4.1.5 Agricultural and Horticultural premises installation shall be in accordance with NIS IEC60364-7-705.

7.4.4.1.6 Households and similar electrical appliances particular requirement for commercial dispensing appliances and vending machines shall be in accordance with NIS IEC 60335-2-75.

7.4.4.1.7 The installations at Marinas and similar locations shall meet the requirements of NIS

NIS IEC 60364-7-709.

7.5 Erection and Inspection of electrical installations

7.5.1 Erection

The following shall be considered when erecting electrical installations at the user's site:

a. Good workmanship by NEMSA certified contractor and proper materials shall be used in the erection of the electrical installation. Electrical equipment shall be installed in accordance with the instructions provided by the manufacturer of the equipment.

b. The characteristics of the electrical equipment, as determined in accordance with Clause 133 as provided in NIS IEC 60364-part 1, shall not be impaired during erection.

c. Conductors shall be identified in accordance with NIS IEC 60446. Where identification of terminals is necessary, they shall be identified in accordance with NIS IEC 60445.

d. Connections between conductors and other electrical equipment shall be made in such a way that safe and reliable contact is ensured.

e. All electrical equipment shall be installed in such a manner that the designed heat dissipation conditions are not impaired.

f. All electrical equipment likely to cause high temperatures or electric arcs shall be placed or guarded so as to minimize the risk of ignition of flammable materials. Where the temperature of any exposed parts of electrical equipment is likely to cause injury to persons, those parts shall be so located or guarded as to prevent accidental contact therewith.

g. Where necessary, for safety purposes, suitable warning signs and/or notices shall be provided.

h. Where an installation is erected by using new materials, inventions or methods leading to deviations from the rules of NIS IEC 60364 series, the resulting degree of safety of the installation shall not be less than that obtained by compliance with NIS IEC 60364 series.

i. In the case of an addition or alteration to an existing installation, it shall be determined that the rating and condition of existing equipment, which will have to carry any additional load, is adequate for the altered circumstances. Furthermore, the earthing and bonding arrangements, if necessary for the protective measure applied for the safety of the addition or alteration, shall be adequate.

7.5.2 Initial Inspection

Electrical installations shall be inspected and certified by NEMSA certified contractor before being connected to the grid and after any important modification to confirm proper execution of the work in accordance with NIS IEC 60364-part 1.

7.5.3 Periodic verification

It is recommended that every electrical installation shall be subjected to periodic inspection and testing

7.6 Protection for safety in Electrical Installations/Consumer's premises

7.6.1 General

The requirements stated from section 7.2 to 7.2.13 are intended to provide for the safety of persons, livestock and property against dangers and damage which may arise in the use of electrical installations. The requirements to provide for the safety of livestock are applicable in locations intended for them. It is mandatory for all the Consumer in the Nigeria Electricity Supply Industry (NESI) to equip their premises/property to provide the various protection devices prescribe in this section.

NOTE In electrical installations, the following hazards may arise:

a. shock currents;
b. excessive temperatures likely to cause burns, fires and other injurious effects;
c. ignition of a potentially explosive atmosphere;
d. under-voltages, over-voltages and electromagnetic influences likely to cause or result in injury or damage;
e. power supply interruptions and/or interruption of safety services;
f. arcing, likely to cause blinding effects, excessive pressure, and/or toxic gases; and
g. mechanical movement of electrically activated equipment.

7.6.2 Protection against electric shock

7.6.2.1 Basic protection (protection against direct contact For low-voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact.

Protection shall be provided against dangers that may arise from contact with live parts of the installation by persons or livestock.
This protection can be achieved by one of the following methods:

a. preventing a current from passing through the body of any person or any livestock; and
b. limiting the current which can pass through a body to a non-hazardous value.

7.6.2.2 Fault protection (protection against indirect contact)

For low- voltage installations, systems and equipment, fault protection generally corresponds to protection against indirect contact, mainly with regard to failure of basic insulation.

Protection shall be provided against dangers that may arise from contact with exposed-conductive-parts of the installation by persons or livestock.

This protection can be achieved by one of the following methods:

a. preventing a current resulting from a fault from passing through the body of any person or any livestock;
b. limiting the magnitude of a current resulting from a fault, which can pass through a body, to a non-hazardous value; and
c. limiting the duration of a current resulting from a fault, which can pass through a body, to a non-hazardous time period.

7.6.2.3 Protection against thermal effects

The electrical installation shall be so arranged to minimize the risk of damage or ignition of flammable materials due to high temperature or electric arc. In addition, during normal operation of the electrical equipment, there shall be no risk of persons or livestock suffering burns.

7.5.2.4 Protection against overcurrent

Persons and livestock shall be protected against injury and property shall be protected against damage due to excessive temperatures or electromechanical stresses caused by any over-currents likely to arise in conductors. Protection can be achieved by limiting the overcurrent to a safe value or duration.

7.6.2.5 Protection against fault currents

Conductors, other than live conductors, and any other parts intended to carry a fault current shall be capable of carrying that current without attaining an excessive temperature. Electrical equipment, including conductors shall be provided with mechanical protection against electromechanical stresses of fault currents as necessary to prevent injury or damage to persons, livestock or property. Live conductors shall be protected against over-currents arising from faults.

7.6.2.6 Protection against voltage disturbances and measures against electromagnetic influences

a. Persons and livestock shall be protected against injury and property shall be protected against any harmful effects as a consequence of a fault between live parts of circuits supplied at different voltages.

b. Persons and livestock shall be protected against injury and property shall be protected against damage as a consequence of over-voltages such as those originating from atmospheric events or from switching.

NOTE: protection against direct lightning strikes, refer to NIS IEC 62305 series.

c. Persons and livestock shall be protected against injury and property shall be protected against damage as a consequence of under-voltage and any subsequent voltage recovery.

d. The installation shall have an adequate level of immunity against electromagnetic disturbances so as to function correctly in the specified environment. The installation design shall take into consideration the anticipated electromagnetic emissions, generated by the installation or the installed equipment, which shall be suitable for the current-using equipment used with, or connected to, the installation.

7.6.2.7 Protection against power supply interruption

Where danger or damage is expected to arise due to an interruption of supply, suitable provisions shall be made in the installation or installed equipment.

7.6.2.8 Earthing of Consumer Installation

The requirement for earthing in consumer's installation shall be in accordance with the specifications in chapter 11 of this Regulation.

7.6.2.9 Testing of Consumer Installation

Testing of consumer Installation shall be carried out in accordance with the sequence of test as specified in clause 10.3.2.2 of this Regulation.

Chapter 8: Protection, Control and Metering

8.1 Protection Systems Installations

Protective Relaying System adequately sectionalized and graded protective relaying scheme shall be provided for transmission lines, transformers and bus bars so as to automatically isolate the faulty equipment as per preset duty and, thus, minimize the damage to the equipment in the event of faults and abnormal conditions. All main protection relays shall be of numerical type and communication protocol shall be as per NIS IEC-61850.

8.1.1 Transmission Systems Protection

The transmission system protection scheme shall be designed to be:

- Reliable
- Sensitive
- Secured
- Selective and
- Dependable

The transmission system protection shall cover

8.1.1.1 Line and Feeder Protection: 330kV and 132kV line protection

8.1.1.1.1 Each line feeder shall be protected with the following protective devices:

a. Main and back up distance protection at each end of each line. The main protection relay shall be from a different manufacturer and of a different model from the back-up protection
b. Main and back-up line differential protection with a relay located at each end linked by means of a digital channel. The relay of the main protection shall be from a different manufacturer and of a different model from the back-up protection relays

8.1.1.1.2 The line protection circuit shall allow for total fault clearing time ranging from 5-6 cycles including the circuit breaker operating time. The protection circuit shall be designed for single or three phase trip with single or three poles reclosure considering the following:

a. Reclosure is allowed for phase to ground fault
b. Reclosing delay shall be between 0.75-2sec
c. When the breakers are tripped, the reclosure shall be sequenced such that the circuit breaker (from one end) closes on a dead line and then the remote end circuit breaker by synchronism check

8.1.1.2 Overvoltage Protection

a. The overvoltage protection shall monitor the voltage of each phase with three trips settings between 110-150% overvoltage with time delay between 1.0 and 0.125sec correspondingly. The overvoltage protection circuit shall produce three phases local and transfer trip.

b. Digital channel links of 64kbits/sec maximum capacity shall be available for any communication between line ends relays. OPWG or PLC channels shall also be available as back-up transmission path.

8.1.1.3 Power Transformer and Shunt Reactor Protection

a. Power transformer protection shall compose of:

i. A three phase bias restraint differential relay,

ii. Three phase and neutral overcurrent relay with instantaneous and inverse time characteristics,

iii. Transformer mechanical devices such as gas relay, over-temperature relay, oil level relay, tap changer failure relay.

b. Differential protection shall cover all windings and overcurrent protection shall be used for all windings and neutral.

8.1.1.4 Breaker Failure Protection

The operation of line breaker failure protection is described as follows:

a. When the circuit breaker is subject to protective tripping, a time delay relay starts while an instantaneous element supervises the current passing through the circuit breaker

b. If the Overcurrent Element is not reset at the time the delay elapses, a trip signal is sent to the adjacent protection zone trip relay directly or by teleprotection.

8.1.1.5 Shunt capacitor Bank Protection

a. The main feeder Overcurrent Protection and the fuses of the individual capacitor unit shall provide the shunt capacitor protection. This is complemented by neutral overcurrent relay (tuned to fundamental frequency) that will give an alarm when too much unbalance of the bank occurs. This happens when various capacitor bank unit fuses have blown out and need replacement.

b. All capacitor banks installed on 132kV and above shall be provided with the following protection:

i. Instantaneous and time lag phase overcurrent relay,

ii. Instantaneous and time lag neutral earth fault relay,

iii. Under and overvoltage relays,

iv. Lightning and surge protection.

8.1.1.6 Busbar Protection

The two main buses (breaker and a half) shall be protected by means of differential protection relays connected to CT located on the feeder side of the associated breakers. Normally, feeder protection covers the buses located downstream on the feeders. However, when the feeder disconnect switch is open and the ring bus is closed, the corresponding feeder bus section comprised between the two circuit breakers has to be protected by a separate bus differential relay. This relay shall be provided in each of the feeder protection panels.

8.1.1.7 ***Synchronism Check***

In order to prevent closure of a 330/132kV circuit breaker out of synchronism a circuit breaker closure shall be conditioned by a synchronism check relay using LLDB (Live Line Dead Bus) and LBDL (Live Bus Dead Line) schemes. Each line feeder circuit breaker and autotransformer circuit breaker shall be supervised by an individual synchronism check relay.

8.1.1.8 ***Wide Area Protection***

i. Wide area protection may be implemented to ensure the security, reliability and stability of the grid system.
ii. The owner of a network shall determine when it becomes reasonably necessary to implement Wide Area Protection and propose an implementation plan in writing to NERC.

8.2 Power Systems Metering Installations

a. The Energy Metering System as specified in Nigerian Nigeria Metering Code version 02 read with its amendment(s) dealing with installation and operation of meters including interface Grid meters shall be installed and used for tariff metering for Bulk Interutility power flows at the trading Point - Point of Common Coupling (PCC) - between TCN, Discos and Gencos. The metering system shall be installed on each circuit as a self-contained device for recording and measurement of active energy and reactive energy and other system parameters as detailed below:

i. Mega Watt Hour Meter (MWh),
ii. Mega Volt Ampere Meter (MVA),
iii. Mega Watt Meter (MW)
iv. Mega VAr Meter (MVAr)
v. Power Factor meter (pf)
vi. Kilo Volt meter (kV)
vii. Ammeters (A)
viii. Frequency Meters
ix. Fault Locators

8.3 Digital Events Recorders

8.3.1.1 ***330kV Substations***

Digital Event recorders shall be installed in every 330kV substation. The devices above shall be numerical, compatible with mass data storage system and shall be synchronous. Measurement shall be taken synchronously and shall be time stamped.

8.3.1.2 ***Display of Three Phase Voltages and Currents***

In the Control Room, there shall be continuous display of three-phase voltage and current values.

8.3.1.3 *Electronic Records of Data*

The log records shall be archived for a minimum of 90 (ninety) days (Using data concentrators). The fault recorders shall also have digital interphase for remote acquisition.

8.4 SCADA Systems Installations

8.4.1 SCADA Requirements - NIS IEC 61850

8.4.1.1 *SCADA/EMS Software Standards*

All SCADA/EMS software shall comply with the industry-accepted software standards produced by national and international organizations, such as ANSI, ISO, NIS IEC, and IEEE and shall be CIM (Common Information Model) compliant.

8.4.1.2 *Prohibition of Proprietary Software*

The use of proprietary system services software shall be prohibited.

8.4.1.3 *Computer hardware*

The requirement of hardware shall be optimized for servers/processors where one or more applications can be combined or distributed in any combination with adequate redundancy.

8.4.1.4 *SCADA Control Room*

SCADA Control Room shall be constructed in accordance with NIS NIS IEC 61850 standard.

8.4.1.5 *Standards for Remote Terminal and Phasor Measurement Units*

Remote Terminal Units (RTUs) and Phasor Measurement Units (PMU) at Load Dispatch Centre shall comply with NIS NIS IEC 61850.

8.4.1.6 *Communication Between IEDs*

Communication between Intelligent Electronic Devices (IED) shall be in accordance with NIS NIS IEC 61850 and Communication between Substation Automation System (SAS) and power plant devices shall comply with NIS IEC 608-70-104.

8.4.1.7 *Use of Geographic Information Systems*

The use of Geographic Information System (GIS) shall be employed by electric utilities, for the purpose of keeping accurate location inventory of physical assets and for complex system analysis as they relate to faults, network optimization and load forecasting for normal service.

Chapter 9: Classification of Equipment and Types of Tests

9.1 General Provisions

Equipment used in the distribution network shall be classified as outdoor or indoor equipment. Indoor equipment shall consist of equipment used in distribution network installed within a building or an enclosure free or shielded from direct sunlight.

Examples include but not restricted to;

a. Transformer control panels,
b. Line/feeder control panels,
c. Battery banks,
d. Chargers and Tripping units,
e. Communication gadgets among others.

Outdoor equipment shall consist of equipment used in distribution network installed outside a building or any enclosure and not protected from direct sunlight or other weather effects.

Examples include but not restricted to;

a. Transformers,
b. Circuit breakers,
c. Power isolators, among others.

9.2 Types of Tests

The condition and service reliability of equipment used in distribution network shall at all times be kept in the most efficient and safe operating condition while undergoing periodic basic and necessary tests.

These tests shall comply strictly with the provisions of NIS IEC 60726. Basic tests to be carried out on distribution equipment shall include but not limited to the following;

a. Power transformer routine tests:
   i. Induced voltage test,
   ii. voltage ratio measurement and check of polarities and connections,
   iii. no-load current and no-load loss measurement,
   iv. winding resistance measurement,
   v. short-circuit impedance and load loss measurement,
   vi. partial discharge measurement,
   vii. Dielectric tests – Separate-source voltage withstand test,
   viii. Insulation resistance test,

ix. Stability Test.

b. Distribution Transformers routine tests:

i. Measurement of voltage ratios,
ii. Vector group tests,
iii. Measurement of high voltage and low voltage winding resistances,
iv. Dielectric test of high voltage and low voltage winding(s),
v. Induced overvoltage tests,
vi. Measurement of no-load losses and no-load current,
vii. Measurement of load losses and impedance voltage with off-circuit tap changer in the nominal position,
viii. Measurement of the resistances of the insulating system between high voltage, low voltage and tank (earth),
ix. Single phase excitation tests,
x. Insulation resistance test.

c. Basic Tests for Switchgears (Circuit breakers and panels):

The following switch gear routine tests shall apply but are not limited to:

xi. Wiring and function tests,
xii. Contact resistance tests,
xiii. Low voltage circuit insulation test of panels,
xiv. High voltage power frequency test,
xv. High voltage insulation test.

9.3 Power and Distribution Transformers

9.3.1.

a) Standard power transformer capacities shall be:
2.5 MVA, 5 MVA, 7.5 MVA, 10 MVA, 15 MVA and up to 30 MVA suitable for 33000/11000 V at the secondary side of the transformer, at a nominal frequency of 50 Hz; and
b) Distribution transformers shall be 25 KVA, 50 KVA, 100 KVA, 200 KVA, 300 KVA, 500 KVA, 1000 KVA, 1500 KVA and 2500 KVA suitable for 33 kV or 11 kV operations with 400 V at secondary side of the transformer, at a nominal frequency of 50 Hz.
c) All transformers must comply with the provisions of NIS IEC 60076-1 to NIS IEC 60076-10 including other international standards on distribution and power transformers. The transformers shall be constructed to achieve lower no-load losses, noise levels and high operating efficiency without posing risk(s) to lives and property.
d) The transformers shall operate at a minimum operating efficiency of 95%.

9.3.2. Materials:

The transformer core shall be cold-rolled grain-oriented magnetic silicon steel or amorphous metal. Winding material shall be copper. Materials other than copper shall be used with approval duly obtained from Nigerian Electricity Regulatory Commission (NERC).

9.3.3. Transformer Terminal Designations for all Transformers:

9.3.3.1. Capital Letters designate a primary or high-voltage terminal viewed from the source of supply into the substation transformer, the primary terminals are marked “R, Y, B” or “A, B, C” from left to right. The R or A bushing is always at the upper left. The sequence on the high voltage side shall be “R, Y, B” or “A, B, C”.

9.3.3.2. Small letters designate a secondary or low-side terminal.

The sequence on low voltage side shall be (Example: “r, y, b” or “a, b, c” and “n”

The transformer shall be designed as to suppress or eliminate the harmonics voltages and current, especially in the 3^{rd}, 5^{th} and 7^{th} order harmonics, eliminate waveform distortions that reduce electromagnetic and electrostatic interfaces in communication circuits and higher frequency disturbances. Filters shall be installed against harmonics in the networks.

9.3.4. Environmental Impact

Impact of transformer operation on the following hazardous and loss conditions shall be at the barest minimum:

1. Noise pollution.
2. Land pollution, due to escaping oil in case of leaks.
3. The use of PCBs (polychlorinated biphenyls) in cooling liquids.
4. Energy losses in transformers.
5. Visual pollution to the environment caused by the siting of transformers and substations without due consideration to the impact on the landscape.
6. Safety of people and environment

9.3.5. Continuity Test

Every winding continuity test shall be carried out on all transformers using appropriate method and equipment to detect and confirm open circuit fault in the winding and terminals.

9.3.6. Vector Group

To confirm the nameplate specification on every transformer, Vector group verification test shall be carried out in accordance with relevant NIS NIS IEC 60076-1.

9.3.7. Ratio Test

A ratio test shall be carried out on power transformers to confirm the rated voltage ratio of the transformers.

This process shall be repeated for all tap position to further confirm the nameplate specification by the manufacturer.

9.3.8. **Magnetic Balance Test**

To identify interturn fault on magnetic imbalance in the core, this test shall be carried out as routine test in accordance with NIS NIS IEC 60076-1.

9.3.9. **D.C. Winding Resistance Check**

9.3.9.1. This test shall be carried out with reference to NIS NIS IEC 60076-1, using appropriate test method.

9.3.9.2. Test results obtained shall be compared with the manufacturers winding resistance to ascertain level of deterioration.

9.3.10. **Insulation Resistance Test**

9.3.10.1 Electric lines and apparatus of the licensee for use at high voltage shall not be connected to a system for the purposes of the supply of energy unless the insulation of the electric lines and apparatus has withstood either–

(a) the test prescribed in that behalf in the appropriate Nigerian Standard (NIS NIS IEC 60076-3) or

(b) in case where no such tests have been prescribed, the continuous application between conductors and earth during a period of not less than fifteen minutes of alternating current either at testing voltage equal to at least one and one –quarter times the normal working voltage to which the electric lines of apparatus will be subject under conditions of supply, or at a testing voltage equal to the aforesaid working voltage with the addition of 10,000 volts, whichever be the higher.

9.3.10.2 Provided that for the purpose of such alternative tests–

(a) the testing voltage between the outer conductor and earth in cases where the outer conductor of an electric line having concentric conductors is to be connected directly with earth shall be 1,000 volts;

(b) the aforesaid working voltage between any phase of an alternating current system and earth in cases when the neutral conductor of the said system is not to be connected with earth shall be deemed to be the voltage between phases;

(c) the duration of the test may be reduced to one minute in the case of apparatus for use at high voltages subject to the testing volts being increased so as to equal not less than one and one-half times the aforesaid working voltage, or aforesaid working voltage with the addition of 20,000 volts whichever be the less;

(d) Direct current may be used instead of alternating current subject to the testing voltage being increased so as to exceed by at least fifty per cent the corresponding testing voltage prescribed for alternating current.

9.3.10.3 If the testing prescribed in this Regulation are made prior to the said electric lines and apparatus being placed in position for the purposes of the supply of energy, the said electric lines and apparatus after having been placed in position and before being connected to the system shall have withstood a further test for resistance of insulation either by the application of the tests

9.3.10.4 As prescribed in this Regulation whenever reasonably practicable, or by the application of a testing voltage of not less than 1,000 volts between conductors and also between conductors and earth during a period of not less than one minute.

9.3.10.5 Where any electric line has been disconnected from a system for alteration or repair, such electric line or apparatus shall not be reconnected to the system until the licensee have applied the test prescribed in Clause 9.3.10.3 of these Regulation and have satisfied themselves that the insulation of the electric line or apparatus and the phase sequence of the system are in sound condition

9.3.10.6 All power transformers prior to their installation and commissioning shall be sufficiently tested and confirmed to possess insulation resistance of not less than 5 to 10 times its rated voltage level. And this value must be reasonably maintained as to prevent danger or interruption of supply as far as is reasonably practicable.

9.3.11. Phasing and Polarity

Phasing of the distribution transformers shall follow the sequence R –Y – B on the primary winding and r – y – b – n on the secondary in a transformer of Delta – Wye vector group. The polarity shall be subtractive.

9.3.12. Continuity Tests

Continuity tests shall be performed on transformers to determine winding continuity on both sides of the transformer and establish the good operating conditions of the transformer.

9.3.13. Vector group

The transformer winding configurations shall be Dy 11 and Dy 1.

9.3.14. Ratio Test

Transformer voltage ratio test shall be performed on transformers within accuracy range of ±0.1%

9.3.15. Magnetic Balance Tests

Magnetic balance test shall be carried out on transformers to determine inter turn faults and magnetic imbalances required to establish functionality or otherwise of the transformer.

9.3.16. DC Winding Resistance Check

DC winding resistance check shall be performed on a transformer to determine faulty joints or tap switch contacts necessary for ensuring that the windings are maintained in healthy operating conditions.

9.3.17. Insulation Resistance Tests

Insulation resistance tests shall be performed on transformers to establish insulation resistance values of transformer windings to ground in comparison to acceptable values required for efficient and safe operations of the transformer.

9.3.18. Circulating Current Test

Circulating Current Test shall be carried out in conformity with the provisions of NIS IEC 60076-1-11 and NIS IEC 60076-5.

9.3.19. Capacity Confirmation Tests

Transformer capacity shall be confirmed through capacity confirmation test within a 1% error margin.

9.3.20. Magnetizing Current Tests and Core Losses

The transformer shall maintain very low value of magnetizing current and core loss in accordance with NIS IEC 60076-1-94.

9.3.21. Efficiency and Regulation Tests

The transformer shall be designed to operate at maximum efficiency with a voltage Regulation between 2 to 5%.

9.3.22. Temperature Rise

The provisions of NIS IEC 60076-1-8.3, -2 and -11 shall be strictly complied with.

9.3.23. Transformer Oil Tests

9.3.23.1. Transformer Oil Test and Furan Analysis shall be performed to ensure consistency of quality and reliability of transformer oil.

9.3.23.2. Power transformer prior to its installation arrangement shall be made to sample the transformer oil in its entire chamber and put to test in accordance with the specification of this standard. The test to be conducted shall include part or all analysis detailed thus (1) Dielectric strength test (2) Furan analysis (3) Tan delta analysis and (4) Dissolved gas analysis test.

9.3.24. Dissolved Gas Analysis

9.3.24.1. Transformer Oil shall be tested and analyzed to determine the different dissolved gases contained in the transformer oil as to maintain its quality and reliability in power equipment.

9.3.24.2. Dissolved gas analysis shall be carried out on all transformers periodically in accordance with NIS/NIS IEC 60557.

9.3.25. Transformer Auxiliaries

The provisions of NIS IEC 60076-1 as it relates to Transformer Auxiliaries shall be strictly complied with.

9.3.26. Oil Surge Relay

Oil surge relay shall be installed for the detection of possible contamination of transformer oil due to oil surge.

9.3.27. Arcing Horn

9.3.27.1. All transformers from 33 kV shall be provided with arcing horn.

9.3.27.2. Transformer bushings shall be provided with arcing horn(s) to mitigate effects of flash over due to surge and lightning.

9.4 Earth Resistance Tests

9.4.1.1 Earth resistance tests shall comply with the requirements of the Nigerian Code of Practice for Earthing (NCP 9).

9.4.1.2 Earthing resistance test shall be carried out on every installation to ensure efficient earthing

a. Prior to energizing electrical lines, equipment and apparatus.
b. Periodically during the life cycle of the installation.

9.4.1 Transmission and Distribution Requirements

The acceptance criteria for earthing installation on the transmission lines, equipment and apparatus shall among other criteria have value of earth electrode resistance of less than 1 Ohm. All HV/EHV installation shall be controlled by an earth leakage protective device to disconnect supply instantaneously on occurrence of an earth fault or leakage of current to earth. It shall be capable of passing maximum earth fault current to earth. The passage of fault current shall not result to any thermal or mechanical damage to the insulation of connected plant and equipment, and shall ensure equi-potential gradient within the power system. No dangerous potential gradients (step or torch) shall occur under normal or abnormal operating condition. The earthing shall minimize electromagnetic interference between power and control/communication equipment and ensure safety to personnel.

9.4.2 Soil Resistance Tests

9.4.3.1. To design most economically and technically sound earthing system for a high voltage substation accurate soil resistivity test and its variation with in substation soil shall be carried out.

9.4.3.2. Soil Resistance Test shall be performed for all installations to ensure the maintenance of an acceptable earth resistance value in accordance with the provision of NCP9.

9.4.3.3. Soil Thermal Resistivity

Soil Thermal Resistivity shall be determined for cable installation systems in accordance with NIS IEC 60287-2-11.

9.4.3 Current Transformers

Current Transformers of suitable ratios, burden and accuracy shall be provided as integral requirements for efficient distribution networks protection and metering.

9.4.4.1. Insulation Tests

Insulation Tests shall be carried out on a Current Transformer (CT) in order to determine its operating conditions in achieving its intended purpose. These tests shall be carried in strict conformity with NIS IEC 60071 and NIS IEC 60085.

9.4.4.2. Excitation Tests

Excitation Test shall be performed on Current Transformers (CTs) to confirm that the CT is not saturated and will operate within specifications at the rated burden.

9.4.4.3. Primary Injection/Ratio Tests

Primary Injection / Ratio tests shall be performed on a Current Transformer to determine the CT accuracy compared to the accuracy class.

9.4.4 Voltage Transformers

9.4.5.1. Continuity Checks

a. All voltage transformers shall be subjected to, but not limited to, the following tests for effective performance:

i. VT continuity winding
ii. Polarity
iii. Phase and Magnitude
iv. Winding Resistance
v. Secondary Burden amongst others.

b. These checks shall be performed in accordance with NIS NIS IEC 60044-7.

9.4.5.2. Insulation Tests

Insulation resistance of a voltage transformer shall comply with the provisions of NIS NIS IEC 60044-2 (2000-1).

9.4.5.3. Polarity Tests

Polarity Tests shall be performed on voltage transformers to establish voltage transformation accuracy as compared with declared nameplate data and shall comply with the provision of NIS IEC 60044-7.

9.4.5.4. Ratio Tests

Ratio Tests shall be performed on voltage transformers in accordance with relevant sections of NIS IEC 60044-7.

9.5 High and Medium Voltage Cables

9.5.1 Dielectric Tests

Dielectric Tests shall be performed on medium and high voltage cables to confirm their insulation capability according to NIS IEC 60502-2, NIS IEC 60060.

9.5.2 Cable Fault Location

Faulty Cables shall be tested using on-site fault location technique to identify flash over at weak points along the cable routes for easy localization.

9.5.3 Cable Route Tracing

Location of the position of fault on faulty cables shall be achieved through route tracing and the exact position identified through the process of pinpointing.

9.6 Circuit Breakers

The design, selection and specification of Circuit Breakers for use in distribution substations shall take into consideration the environmental conditions in which the circuit breaker will be operated.

9.6.1 Standards & Specifications

9.6.1.1 Circuit breakers shall be outdoor or indoor type and could be of metal clad - gas insulated and / or vacuum type and / or oil circuit breakers. The design, engineering, manufacture, testing, inspection and performance of these circuit breakers shall comply with the requirements of NIS IEC 62271-100 & 200.

9.6.1.2 Circuit breakers for use for LV applications shall comply with the requirements of the respective standards NIS IEC 60947-1 & -2 and NIS IEC 60898.

9.6.2 Scope of Tests

The recommended scope of tests for indoor and outdoor circuit breakers shall be as specified in 9.6.1.1 and 9.6.1.2.

9.6.3 Breaker Timing Tests

The recommended Breaking Timing Tests for indoor and outdoor circuit breakers shall be as specified in 9.6.1.

9.6.4 Auxiliary Switches

Auxiliary switches for remote signalling and interlocking shall be provided for the safe operation and maintenance of medium voltage circuit breakers at substations in accordance with NIS IEC 62271-100 & 200.

The design, selection and specification of auxiliary switches to be mounted on substation circuit breakers for both indoor and outdoor types shall be of mechanism-operated control and/or truck-operated contact auxiliary switches.

9.6.5 Oil Circuit Breakers

The design, selection, specification, operation and maintenance of oil circuit breakers shall be in accordance with the requirements of 9.6.1.

9.6.6 Gas Insulated Circuit Breakers

The design, selection, specification, operation and maintenance of gas-insulated circuit breakers shall be in accordance with the requirements of **9.6.1**.1

9.6.7 Vacuum Circuit Breakers

The design, selection, specification, operation and maintenance of vacuum circuit breakers shall be in accordance with the requirements of **9.6.1**.1

9.6.8 Earth Resistance and Continuity Tests

9.6.8.1 Earth Resistance and Continuity Tests shall be carried out to determine the effectiveness of the earthing system for the safe operation and maintenance of equipment installed in substations and shall be consistent with the requirements of NCP09.

9.6.8.2 All substation equipment shall be solidly earthed and the continuity to earth of all metallic parts shall be regularly confirmed and established in conformity with the minimum specified values given in 11.14.

9.6.9 ***Final Inspection by Utilities***

Final inspection on all new installations and major maintenance works shall be carried out on all equipment deployed prior to the commissioning by a team of competent COREN registered electrical engineers with a minimum of 10 years cognate experience.

9.7 Lightning Arresters

9.7.1 This specification defines the minimum engineering design requirements for protection devices to be deployed for indoor and outdoor substations against lightning strikes.

9.7.2 Distribution networks and associated structures shall be effectively protected against lightning strikes. The Basic Impulse Level (BIL) of Lightning Arresters shall be less than that of the equipment installed in the network.

9.7.3 ***Standards and Specifications***

The design, selection and specification of lightning arresters for use in distribution networks shall take into cognisance amongst other considerations the prevailing atmospheric conditions (Isokeraunic level) of the environment in accordance with the requirements of NIS IEC 60099-5, 6 & 8, and NIS IEC 62305-1, 2, 3 & 4.

9.7.4 ***Ratings***

The ratings of lightning arresters shall be as stated in Table 9.7.4

Table 9.7.4

Typical Arrester Ratings for System Voltages

Arrester Rating (KV)			Arrester Rating (KV)		
Nominal System L-L Voltage (KV)	**Grounded Neutral Circuits**	**High Impedance Grounded, Ungrounded, or Temporary Ungrounded**	**Nominal System L-L Voltage (KV)**	**Grounded Neutral Circuits**	**High Impedance Grounded, Ungrounded or Temporary Ungrounded**
2.4	2.7	3.0	69	54	-
				60	-
				-	66
4.16	3.0	-		-	72
	4.5	4.5		90	-
				96	-
				108	108
	4.5	-	115	-	120
4.8	5.1	5.1		108	-
	-	6.0		120	-
				-	132
				-	144
	6.0	-			
	-	7.5			
	-	8.5	138	120	-
6.9				132	-
				144	144
	9.0	-		-	168
	10	-		172	-
	-	12		180	-
	-	15		192	-
	10	-		-	228
12.47	12	-		-	240
	-	15	161	258	-
	-	18		264	-
	18	-		276	-
	21	-		288	288
	24	24		294	294
	-	27		300	300
13.2, 13.8	27	-		312	312
	30	-	230	300	-
	-	36		312	-
	-	39		336	-
	39	-		360	-
	-	48			
23, 24.94					
			345		
34.5					
46			400		

9.7.5 ***Tests***

Annual tests shall be carried out on lightning arresters to ensure their operational effectiveness in conducting to earth over-voltage surges that may occur during lightning strikes in accordance with the requirements of NIS IEC 60099-6 & 8 on testing.

9.7.6 ***Testing Methods***

Test methods for lightning arresters shall be in accordance with the requirements of NIS IEC 60099-8 and as may be specified by the original equipment manufacturer.

9.7.7 ***Acceptance Criteria***

The acceptable nominal voltage for lightning arresters shall be in accordance with the values specified in **table 9.7.2**

9.7.8 ***Earth Resistance and Continuity Tests***

Earth Resistance and Continuity Tests shall be carried out to determine the effectiveness of Lightning Arresters installed for the safe operation and maintenance of the network in accordance with the values specified in **11.15**

9.7.9 ***Insulation Resistance***

A d.c. voltage not less than twice the normal voltage of the supply (r.m.s. value of a.c. supply) shall be applied for the measurement of insulation resistance of Lightning Arresters.

9.8 Substation D.C Supply (Batteries and Battery Charger System)

Distribution Substations shall be provided with a d.c. battery bank and battery charger systems as an independent source of energy, separate from the primary a.c. supply source, to ensure continuity of supply to substation control systems that require energy for their continuous operation.

9.8.1 ***Standards and Specifications***

9.8.1.1 The design, selection and specification of battery and battery charging system for use in distribution substations shall be such that sufficient energy is available for normal operation of substation protection and control system including other d.c. operated auxiliaries within the substation.

9.8.1.2 Batteries used for substation d.c. supply shall be of vented flooded lead acid type.

9.8.1.3 The nominal d.c. operating voltage at substations shall be 110V. The d.c. supply cabling shall be sufficiently sized to prevent voltage drop at the load end, particularly for long cable runs.

9.8.2 ***Installations***

9.8.2.1 **Chargers & Tripping Units**

9.8.2.1.1 Batteries shall be charged in accordance with the manufacturer's specification.

9.8.2.1.2 Charge controllers shall be installed to control the battery charge current to maintain float charges.

9.8.2.2 **Battery Banks**

9.8.2.2.1 Distribution substation batteries shall be installed in a separate room provided to house the Battery Banks and shall be placed on metal racks suitably constructed for the purpose and on acid proof tile.

9.8.2.2.2 Every battery shall be so arranged that a potential difference exceeding 50V does not exist between adjacent cells without adequate protections against electrical hazards, and each cell shall be readily accessible from the top of the battery bank and from at least one side.

9.8.3 ***Safety Measures***

9.8.3.1 The room in which batteries are placed shall be effectively ventilated to prevent the accumulation of dangerous and flammable battery fumes. Extractor fans shall be provided at every battery room.

9.8.3.2 Persons entering the room shall be provided with personal protective equipment including nose mask and hand gloves.

9.8.4 ***Testing and Maintenance***

Battery bank installation shall be periodically inspected, tested and maintained to guarantee reliability of service and safety of personnel.

9.8.5 ***Disposal Methods***

Unserviceable batteries shall be safely disposed in a manner that will not constitute hazard to the environment in accordance with the requirements of the National Environmental (Sanitation and Wastes Control) Regulations.

9.9 Relays

9.9.1 **Standards and Specifications**

9.9.1.1 The design, selection and specification of relays for use on distribution substation switchgear shall be of the appropriate type to monitor, protect and measure electrical signals and input and initiate appropriate predetermined changes in the electrical circuit in accordance with NIS IEC 60255-1.

9.9.1.2 The types of relay to be used in distribution substations shall include but not limited to:

i. Electromechanical Relays
ii. Electrostatic Relays
iii. Numerical Relays

9.9.2 **Electromechanical Relays**

Electromechanical relay used on distribution substation switchgears shall comply with the requirements of NIS IEC 61810-1.

9.9.3 **Electrostatic Relays**

Electrostatic relays which are relays that do not have moving parts used on distribution substation switchgears shall be installed and maintained in accordance with the requirements of NIS IEC 60255**.**

9.9.4 Numerical Relays

9.9.4.1 Numerical Relays are Intelligent Electronic Devices (IED) enabled relays using a microprocessor to perform protective, control, and measurement functions. They shall be compatible to telecommunication interfaces.

9.9.4.2 Numerical Relays installed on distribution switchgear shall conform to the requirements of NIS IEC 61850-3.

9.9.5 Relay Tests

9.9.5.1 Relay installed on substation switchgear shall be tested and calibrated at least twice yearly.

9.9.5.2 The test so carried out shall be in accordance with the provisions of NIS IEC 60255 and NIS IEC 61810-7.

9.9.6 Adverse Conditions

Substation Relay selection and specification shall take into consideration the ability of the relays to withstand adverse operating conditions such as excessive temperature rise, high humidity and dusty environment.

9.9.7 Tests on Relay Circuits

Substation relay circuit shall be periodically tested yearly to ascertain the functionality of the relay and associated network devices such as current transformers, voltage transformers to ensure that their performance is still within the specified limits.

9.9.8 Primary Injection Tests

Primary Injection Test shall be carried out once in a year on all substation installed current transformers to confirm the equipment is still within its accuracy classification.

9.9.9 Secondary Injection Tests

Secondary Injection Test shall be carried out once in a year on all substation installed relay current transformer to determine the effectiveness of the operations of the relay at the specified input level.

9.9.10 Pick –up Current

Secondary Injection Tests shall be carried out once in a year to determine the pick-up current of all relays installed in a distribution substation circuit to ensure its conformity with specifications.

9.9.11 Calibration of Relays

9.9.11.1 Injection Tests shall be carried out once in a year on all substation relays to check and make necessary adjustments to the pre-set settings for the optimal performance of the devices.

9.9.11.2 Relays shall be calibrated after every setting change or repair.

9.9.12 Relay Application Tests

Functional Tests shall be carried out quarterly on all installed Injection Substation relay circuits to confirm the operational readiness of the circuits to protect and monitor installed equipment.

9.9.13 Maintenance

9.9.13.1 Maintenance shall be carried out on all installed Injection Substation relays as may become necessary in accordance with the manufacturer's recommendation.

9.9.13.2 Substation Relays found to be inoperative during tests shall be replaced with relays with the same or compatible characteristics.

Chapter 10: Inspection Checks and Preventive Maintenance

10.1 Transmission Installation

All transmission installations shall be inspected, tested and certified by NEMSA before energisation and a report sent to the Commission before listing the infrastructure as a regulatory asset.

Confirmatory checks shall be made on the following:

i. Conductor condition.
ii. Conductor sag and clearance to ground, trees, and structures.
iii. Insulator conditions.
iv. Line hardware for roughness and tightness. Excess inhibitor found should be removed from conductors to prevent corona discharges.
v. Structure vibration and alignment.
vi. Guys for anchors that are pulling out, guy wire conditions, and missing guy guards.
vii. Ground-wire connections and conditions.
viii. Ground resistance at each structure.
ix. Structure footings for washouts or damage.
x. Obstruction light operations for aircraft warning.
xi. Transformers and instrument transformers
xii. Circuit breakers
xiii. Clamps
xiv. Isolators
xv. Re-gravelling of switchyard
xvi. Battery banks
xvii. Chargers
xviii. Protective panels
xix. Lightning arrestors.

10.2 Distribution Installation

10.2.1 Operators of distribution networks shall be responsible for the development and implementation of inspection checklist(s) required for the preventive maintenance of all electrical equipment as specified by the original equipment manufacturer for optimal performance of the equipment.

10.2.2 The preventive maintenance measures shall also take into cognizance the safety of persons in accordance with the requirements of the Nigerian Electricity Health and Safety Code 2014.

10.2.3 The preventive maintenance checklist(s) shall include but not limited to the following facilities, which are critical to system reliability:

i. Poles,
ii. Overhead conductors,
iii. Underground cables,
iv. Transformers,

v. Breakers,
vi. Isolators,
vii. Earthing Switch,
viii. Auto Reclosure,
ix. Sectionalisers,
x. Protective devices,
xi. Substation premises.

10.2.4 A visual inspection of distribution lines and equipment shall be carried out periodically at least once every six months to check for:

i. Broken insulators,
ii. Broken/tilted poles,
iii. Environmental Conditions that may adversely affect the overhead distribution line,
iv. Developing defects or abnormalities on equipment.

10.3 Consumer Installation

10.3.1 Inspection Checks of User's Site Electrical Installations

a. On completion of any new electrical installation or major alteration in the existing installation at the consumer premises, visual inspection shall be made to verify that the electrical equipment as installed is correctly selected and erected in accordance with these Standards. The visual inspection shall include a check on the following items, where appropriate:

i. Adequacy of working space, access, and maintenance facilities,
ii. Connections of conductors,

b. Identification of cables and conductors,
c. Adequacy of the sizes of conductor in relation to current carrying capacity and voltage drop,
d. Correct connections of all equipment with special attention to socket outlets, lamp holders, isolators, switches, residual current devices, miniature circuit breakers, and protective conductors,
e. All safety requirements and equipment with reference to fire barriers and suitable seals and protection against thermal effects,
f. Methods of protection against direct contact with live parts (including measurement of distances where appropriate), i.e. protection by insulation of live parts, or protection by barriers or enclosures,
g. Presence of appropriate devices for isolation and switching,
h. choice and setting of protective and indicative devices,
i. Labelling of circuits, fuses, protective devices, switches, isolators and terminals,
j. Selection of equipment and protective measures appropriate to adverse environmental conditions,
k. Provision of adequate warning signs or notices,
l. Presence of diagrams, instructions and other similar information,
m. Connection of single pole devices for protection or switching in phase conductors only,

n. Methods of fault protection,
o. Prevention of mutual detrimental influence,
p. Presence of under voltage protective devices,
q. Ensuring that appropriate erection methods and good workmanship as well as proper materials have been used in accordance with the provisions of these standards.

10.3.2 Testing of Low Voltage Installations

10.3.2.1 Safety Precaution

Precautionary measures should be taken during testing and the method of tests should be such that no danger to persons or property can occur even if the circuit being tested is defective.

10.3.2.2 Sequence of Tests

a) The tests are to be carried out in the sequence indicated below:
i. Continuity of protective conductors, including main and supplementary equipotential bonding,
ii. Continuity of ring final circuit conductors,
iii. insulation resistance,
iv. Verification of polarity,
v. earth electrode resistance,
vi. effectiveness of earthing
vii. earth fault loop impedance,

b) In the event of any test indicating failure to comply, that test and those preceding, the results of which may have been influenced by the fault indicated, should be repeated after the fault has been rectified.

10.3.2.3 Continuity of Protective Conductors

Every protective conductor, including all conductors and any extraneous conductive parts used for equipotential bonding should be tested for continuity. The test should be made by connecting together the neutral and protective conductors at the mains position and checking between earth and neutral at every outlet by a continuity tester, which should show a reading nearer to zero.

10.3.2.4 Continuity of Ring Final Circuit

a. The ring circuit should be tested from the distribution board. The ends of the two cables forming the phase conductor should be separated, and a continuity test should show a reading near zero between the two; the same tests to be made between the two cables that form the neutral conductor and between the two cables that form the protective conductor.
b. The testing method in Clause 10.3.2.4.a above is only applicable when the ring circuit has been inspected throughout, prior to the test, to ascertain that no interconnection (multi-loops) exists on the ring circuit.

10.3.2.5 *Insulation Resistance Tests*

a. A suitable d.c. insulation tester should be used to measure insulation resistance. Care should be taken to ensure that the insulation of the equipment under test can withstand the test voltage without damage. A d.c voltage not less than twice the normal voltage of the supply (r.m.s. value of a.c. supply) shall be applied for the measurement of insulation resistance, provided that for tests on low-voltage circuits, the test voltage need not exceed 1000/500V d.c.
b. The main switchboard and each distribution circuit should be tested separately. To carry out this test, large installation may be divided into groups of outlets, each containing not less than 50 outlets. The term ‘outlet’ in this case includes every point and every switch. A socket outlet or appliance or luminaries incorporating a switch is regarded as one outlet.
c. When measured with all fuse links in place, all switches and circuit breakers (including, if practicable, the main switch) closed and all poles or phases of the wiring electrically connected together, the insulation resistance to earth should not be less than the 1.0megaohm.
d. When measured between all conductors connected to any one phase or pole of the supply and, in turn, all conductors connected to each other phase or pole of the supply, the insulation resistance should not be less than 1.0megaohm.
e. In carrying out the test:

i. Wherever practicable, so that parts of the wiring may be tested, all lamps shall be removed and all current using apparatus shall be disconnected and all local switches controlling lamps or other apparatus shall be closed.
ii. Where the removal of lamps and/or the disconnection of current using apparatus is impracticable, the local switches controlling such lamps and/or apparatus shall be open.
iii. All electronic devices connected in the installation should be isolated or short circuited where appropriate so that they are not damaged by the test voltage.
iv. Where the circuits contain voltage sensitive devices, the test shall measure the insulation resistance to earth with all live conductors (including the neutral) connected together.

f. Where apparatus is disconnected for the test and the equipment has exposed conductive parts required to be connected to protective conductors, the insulation resistance between the exposed conductive parts and all live parts of the equipment should be measured separately and should have a minimum insulation resistance not less than 1 megaohm.

10.3.2.6 *Polarity Test*

A verification of polarity shall be carried out and ensured that:

i. All fuses and single-pole control and protective devices are connected in the live conductor only;
ii. Centre-contact bayonet and Edison-type screw lamp-holders in circuits having an earthed neutral conductor, have their outer or screwed contacts connected to that neutral conductor; and

iii. Wiring has been correctly connected to plugs and socket outlets and other similar accessories.

10.3.2.7 Earth Effectiveness Test

A portable D.C. Earth Resistance Tester may be used to measure earth resistance provided it has been ensured by inspection throughout the whole length of the earth-continuity conductor that no inductor is incorporated. In these circumstances and subject to the requirements for earth loop impedance, it is satisfactory, where steel conduit forms part or the whole of the earth-continuity conductor, a value of resistance not exceeding 3.0ohm is obtained, or where the earth-continuity conductor is composed entirely of copper, copper-alloy or aluminium, a value of resistance not exceeding 5.0ohm is obtained.

10.3.2.8 Earth Fault Loop Impedance

a. The earth fault loop impedance should be measured by a phase- earth loop tester with a scale calibrated in ohms.
b. Before the test begins, it is essential to establish, by inspection, that the earthing conductor and all relevant earth connections are in place, and that the bonding connection to electricity supplier's earthing facilities is disconnected. Measures should be taken, during the impedance tests especially when the earth leakage protective devices are effectively removed for the duration of the tests, to ensure that the installation is not being used other than by person(s) carrying out the tests.

10.3.2.9 Periodic inspections and tests

a. There shall be a mandatory three-year inspection and testing of all electrical facilities and installations.
b. The results of a periodic inspection and test of an installation, or any part thereof, shall be recorded on an inspection certificate and given by the contractor or by an authorized person acting on his behalf, to the person ordering the inspection.
c. A notice of such durable material as to be likely to remain easily legible throughout the life of the installation shall be fixed in a prominent position at or near the main distribution board of every installation upon completion of the work. The notice shall be inscribed in indelible characters no smaller than those here illustrated and shall read as follows–

   "IMPORTANT" –This installation should be periodically inspected and tested and a report on its condition obtained, as prescribed in the Standard for Electrical Installations.

   Periodic inspection and tests of electrical installation shall be carried out and recorded on an inspection certificate at intervals of not more than three years.

   (i) After having inspected and tested an installation the authorized Inspector, if satisfied that the work has been done in a workmanlike manner in accordance with the requirements of these Standard and if the test made as required by the foregoing provisions of this Part of these Standard have been satisfied, shall certify in writing to the electricity/local electricity distribution company that the installation has been duly inspected and tested and may be safely connected with the source of supply.

Nothing in any such certificate shall relieve the owner or occupier of any premises from the obligation to bring any installation into conformity with these Standards if on any subsequent inspection any defects are discovered which render such installation electrically hazardous.

Chapter 11: Earthing

11.1 General provisions

Earthing is the direct connection to ground of all exposed metallic parts of an electrical appliance or installation for the purpose of limiting voltage build-up relative to ground. Earthing provides common return path to earth of electric current through direct physical connection to ground and it is the reference point in an electrical system from which other voltages are measured.

The earthing of all electrical equipment at Transmission networks shall be of solid type for the purpose of protecting personnel and equipment installed at various locations from lightning strikes, surges, static charges and for the discharge of fault current to earth in accordance with the requirement of NIS IEC 60364-5-54 and the provisions of the Nigerian Code of Practise on Earthing (NCP 09).

11.1.1 Earthing shall be carried out to achieve:

a. Zero potential with respect to ground;
b. Discharge of lightning strikes and over voltages through rod guard, surge arresters, shielding wires to ground;
c. Ensure safety of persons by eliminating voltage gradient with respect to ground;
d. Create through path to ground via the earthing switch and earthed terminals for the purpose of discharging static charges to earth prior to maintenance and repair works.

11.1.2 For every installation operating at any voltage level, the installation earthing terminal shall be provided adjacent to the equipment terminals. Throughout every circuit of such an installation, an earth-continuity shall be provided and connected to the equipment earthing terminals.

11.1.3 All metal work of wiring system (other than current-carrying parts), including cable sheathes and armour, conduits, ducts, trunking, boxes, and catenary wires, shall be connected to appropriate earth-continuity conductors.

11.1.4 Exposed metalwork of all apparatus shall be connected to appropriate earth-continuity conductors.

11.1.5 The earthing terminal of every socket-outlet shall be connected to the earth-continuity conductor of the final sub-circuit. Where the earth-continuity conductor is formed by conduit, trunking, duct, or the metal sheath and/or armour of cables, the earthing terminal of each socket-outlet shall be connected by an appropriate conductor to an earthing terminal incorporated in the associated box or other enclosure. For the purpose of these Regulations, physical connection of adjacent sections of ducts or trunking is necessary to ensure earth-continuity.

11.1.6 At every lighting point with metal fitting, an earthing terminal shall be provided and connected to the earth continuity conductor of the final sub-circuit.

11.1.7 An earthing terminal connected to the earth-continuity conductor of the final sub-circuit shall be provided at every metal lighting switch position unless this takes the form of an earthed metal box having a means of fitting the switch-plate in reliable electrical contact with the box.

11.2 Isolated metal

11.2.1 Where isolation of metal is adopted for the prevention of dangerous earth-leakage currents, it shall be confined to the following items:

a. Short isolated lengths of metal used for the mechanical protection of cables having a non-metallic sheath, other than over-head spans of conduit between buildings or conduit used for protection of cables in circuits operating at voltages exceeding low voltage in discharge-lighting installations.
b. Metal clips used for fixing cables,
c. Metal lamp caps,
d. Small metal parts such as screws or name-plates isolated by insulating material,
e. Metal chains for the suspension of lighting fittings,
f. Metal lighting fitting using filament lamps installed above a non-conducting floor and so mounted, or so screened in non-conducting material, that they cannot readily be touched by a person standing on or within reach of earthed metals.
g. Catenary wires where insulated hangers are used

11.3 Bonding

11.3.1 The consumer's earthing terminal shall be bonded to the metalwork of any public gas services and any water services on the consumer's premises in addition to the connection to the general mass of the earth.

11.3.2 It shall be noted that before the consumer's earthing terminal is bonded to the metalwork of any gas or water service, connection of the earthing terminal to an effective means of earthing shall be completed.

11.3.3 The bonding connections to any gas or water service shall be made as near as practicable to the point of those services within the premises; provided that where there is an insulating section or insert at that point, the connection shall be made to the metalwork on the consumer's side of that section or insert and, in the case of a gas service on the consumer's side of the gas meter.

11.3.4 Copper bonding leads used in compliance with Clause 11.3.3 shall be of cross-sectional area not less than the appropriate value shown in Table 11.1 subject to a minimum size of $6mm^2$. For the purposes of this Regulation, the associated circuit conductor shall be the largest conductor connected into the input side of the consumer's switchgear. Conductors of material other than copper shall have a resistance not exceeding that of the prescribed copper conductor. Connections to the pipes of other services shall be made by means of clamps.

Table 11.3.4

Maximum earth-loop impedances for earth-leakage protection by semi-enclosed fuses or cartridge fuses *rating a fusing factor exceeding* 1.5 *(system operating at* 230-250 *volts to earth)*

Current rating of fuse (A)	***Impedance (Ω)***
5	16
10	8
15	5.3
20	4
30	2.7
45	1.8
60	1.35
100	0.8

11.3.5 The exposed metalwork of all apparatus which is required by these Regulations to be earthed, which might otherwise come into accidental contact with extraneous fixed metalwork shall be either effectually segregated therefrom, or effectually bonded thereto so as to prevent appreciable voltage differences at such possible points of contact. Copper bonding leads shall be of cross sectional area not less than the appropriate value shown in Table 11.1, subject to a minimum of 1.5 mm^2 where the bonding lead is un-enclosed. Conductors of material, other than copper shall have resistance not exceeding that of the prescribed copper conductor.

11.4 Bathrooms

11.4.1 In a room containing a fixed bath or shower cubicle, parts of a lamp-holder within a distance of 2.5 m from the bath or shower cubicle shall be constructed of, or shrouded in, insulating material. Bayonet-type lamp-holders shall be fitted with a protective shield. As an alternative, totally enclosed light fittings may be used.

11.4.2 Every switch or other means of electrical control or adjustment shall be located outside the inner walls of a fixed bathroom normally inaccessible to a person using a fixed bath or shower. This requirement does not apply to insulating cords or cord-operated switches. No stationary appliance having elements, which can be touched, shall be installed within reach of a person using the bath or shower.

11.4.3 In a room containing a fixed bath or shower, there shall be no socket-outlets and there shall be no provision for connecting a portable appliance except for shavers supply unit. In a room containing a fixed bath or shower, electric shavers shall be connected only by means of shaver supply unit where the secondary circuit supplying the output sockets shall be isolated both from the supply mains and from earths

11.5 Protection against earth leakage

11.5.1 The earthing of the consumer's installation shall be effected in such a manner that no fault of negligible impedance to earthed metal shall be so sustained as to cause danger and shall be in accordance with the appropriate requirements of these Regulations

11.5.2 Earth-leakage protection may be effected by means of fuses or, excess-current circuit breaker provided the earth fault current so generated will operate the protective device and so make the faulty circuit dead exceeds–

i. times the current rating of any semi-enclosed fuse having a fusing factor exceeding 1.5, used to protect the circuit (see Table 11.3.4) or
ii. times the rating of any cartridge fuse having a fusing factor not exceeding 1.5, used to protect the circuit, or.
iii. 1.5 times the tripping current of any excess-current circuit breaker used to protect the circuit.

11.5.3 Where the requirement of Clause 11.5.2 cannot be satisfied, earth-leakage protection shall be provided by one or more earth-leakage circuit-breaker for all parts of an installation to which the requirement of earthing applies, installation of the earth-leakage circuit-breakers shall satisfy the test requirements of these provisions.

11.5.4 **Current Operated Earth Leakage Circuit Breaker**

A current-operated earth-leakage circuit breaker shall be used only where the product of its operating current in amperes and the earth-loop impedance in ohms does not exceed 40. Where such a circuit breaker is used the consumer's earthing terminal shall be connected to a suitable electrode.

11.5.5 **Voltage Operated Earth Leakage Circuit breaker**

11.5.5.1 Every voltage-operated earth-leakage circuit breaker shall be arranged to have its operating coil connected between the consumer's earthing terminal (which may serve the whole or part of an installation) and an earth electrode, the connecting lead shall be insulated.

11.5.5.2 The earth electrode used with any voltage-operated earth-leakage circuit breaker shall be placed outside the resistance area of any parallel earth, which may exist, for example where a water heater is installed. If by subdivision of the earthing system, discrimination in operation between a number of voltage-operated earth-leakage circuit breakers is to be afforded, the resistance areas of the associated earth electrodes shall not overlap.

11.6 Earth Continuity Conductors

11.6.1 Every conductor used, as an earth-continuity conductor shall satisfy the requirements stated below:

a. Where the conductor forms part of the same cable as the associated circuit conductors, other than a flexible cable or flexible cord, conductor shall comply with the relevant requirements for the cables.
b. Where the conductor is contained in a flexible cord, it shall have a cross-sectional area not less than that of the largest associated current-carrying conductor,
c. Every cable sheath and/or armouring used as an earth-continuity conductor shall satisfy the relevant requirements of standards mentioned in these Regulations;
d. Conductors of copper other than those mentioned in items (i) to (iii) above, shall

have a cross-sectional area not less than the appropriate value shown in Table 11.2, subject to a minimum of 1.5 mm^2 where the conductor is unenclosed. Conductor of material other than copper shall have a resistance not exceeding that of the prescribed copper conductor.

11.6.2 Installation

11.6.2.1 The installation of every earth-continuity conductor and earthing lead shall satisfy the requirements stated below:

a. Every earth continuity conductor of cross-sectional area 1.5 mm^2 up to and including 6 mm^2, other than copper strip, shall be protected throughout by installing at least equivalent to that provided for a single-core, non-sheathed cable of appropriate size.
b. Where the sheath of earth-continuity conductors is removed adjacent to joints and terminations, earth-continuity conductors of cross-sectional area up to and including 6 mm^2 shall be protected by installing slaving.
c. Bare earth-continuity conductor shall be protected, where necessary, against mechanical damage and corrosion, particularly at terminations.
d. Every bare earth-continuity conductor of the types other than copper strip shall be identified at terminations as appropriate.
e. All joints in earth-continuity conductors shall be mechanically sound, electrically continuous and protected, where necessary, against corrosion,
f. Connections to cable sheaths and/or armouring, and to pipes, shall be soundly made by soldered joints or by clamps. Every clamp shall be so installed as to provide reliable connection without damage to the associated cable or pipe.
g. Copper clad aluminum conductors shall not be used for bonding connections to water pipes likely to be frequently subjected to condensations in normal use, or in other situations where the terminations of the conductors are likely to be exposed to sustained wet conditions. This requirement does not apply to terminations, which may be only initially damp during building construction.

11.6.3 Earthing leads

Pipe such as gas or water, or members of structural metalwork, shall not by themselves constitute an earth-continuity conductor where this is necessary.

11.6.4 Size of Earthing Conductors

The cross-sectional area of every copper conductor used as an earthing lead shall not be less than that shown in Table11.6.4 except that for connection of an earth-leakage circuit-breaker to an earth electrode, where a cross-sectional area of 2.5 mm^2 need not be exceeded. A maximum size of copper conductor of 70 mm^2 cross-sectional areas need not normally be exceeded except for the earthing of a transformer neutral or electrode boiler. For the purpose of this Regulation, the associated circuit conductor shall be the largest conductor connected into the input side of the consumer's switchgear. Every conductor of material other than copper shall have a resistance not exceeding that of the prescribed copper conductor.

Copper-clad aluminum conductors shall not be used for final connections to earth electrodes.

Table 11.6.4

Minimum sizes of copper earthing leads, copper bonding leads and copper earthing continuity conductors not forming part of the same cable as the associated circuit conductors

Nominal cross sectional area of largest associated copper circuit conductor (mm)	***Nominal cross sectional area of earthing lead conductor (mm)***	***Nominal cross sectional area of earthing lead conductor (mm)***	***Nominal cross sectional area of bonding lead conductor (mm)***
1	6	1	1
1.5	6	1	1
2.5	6	1	1
4	6	2.5	1
6	6	2.5	1
10	6	6	2.5
16	6	6	2.5
25	16	16	6
35	16	16	6
50	16	16	6
70	50	50	16
95	50	50	16
120	50	50	16
150	50	50	16
185	70	70	50
240	70	70	50
300	70	70	50
400	70	70	50
500	70	70	50
630	70	70	50

11.6.5 Every connection of an earthing lead to an earth electrode or other means of earthing shall be readily accessible and soundly made by use of soldered joints or clamps: a permanent label indelibly marked with the words “Safety Electrical Earth – DO NOT REMOVE”, in a legible type not less than 4.75 mm high, shall be permanently fixed at the point of this connection.

11.6.6 Where protection against dangerous earth-leakage current by fuses or excess –current circuit breakers is admissible, one of the following methods of earthing shall be employed–

a. Where the supply undertaking provides an earthing point which affords a metallic return path to the means of earthing of the supply system, the earthing lead shall connect the consumer's earthing terminal to this point;
b. Where a means of earthing has not been provided by the supply undertaking, the consumer's earthing terminal shall be connected by the earthing lead to an effective earth electrode or electrodes, such as copper strip or rod, which shall be buried in the ground at a position as near as practicable to the consumers earthing terminal and shall satisfy the tests specified in Appendix 3.

11.6.7 The metalwork of public gas services and water services shall not be used as the sole earth electrode of the installation.

11.6.8 If more than one plate or tubular earth electrode is employed for one earthing system they shall be effectively and efficiently connected together.

11.7 Earthing of Cooking and Heating Appliances

11.7.1 Every fixed electric heating and cooking appliance shall for the purpose of earthing, be provided with a suitable terminal to which the earthing lead shall be connected.

11.7.2 In the case of fixed heating and cooking appliances and of motors of over 3.75 kW an earthing lead other than the conduit shall be taken direct from the appliance or motor to the nearest earth.

11.7.3 Where the multiple-earthed neutral system is used, the earthing lead shall be taken from the neutral bar or stud, and the conduit shall (in addition to being itself earthed) be connected to this earthing lead.

11.7.4 Save as provided in the last preceding paragraph the neutral wire of any system shall not be used as an earthing lead.

11.7.5 Pipes conveying gas, hot water, or an inflammable liquid shall not be used as an earthing system.

11.7.6 Every item of apparatus and every live conductor shall be effectively prevented, by one of the methods described in items (a) to (d) below, from giving rise to danger from earth-leakage currents–

a. Enclosure in insulation which is durable and substantially continuous, i.e., "all-insulated" construction;
b. Double insulation;
c. Earthing of exposed metal parts in accordance with the requirements of these Regulations;
d. Isolation of metal in such a way that is not liable to come into contact with live parts or with earthed-metal.

11.8 Earthing in Commercial Premises

All electric equipment that are installed for public use shall be adequately earthed or insulated to prevent electric shock to people.

11.8.1 Earth leakage

In locations accessible to livestock/humans and in and around agricultural/ commercial buildings, the installation shall as far as is practicable be of “all-insulated” construction.

11.8.2 Provision of Earthing Terminals

a. An earthing terminal, connected to the earth-continuity conductor, shall be provided at every outlet point in the installation.
b. In situations accessible to livestock, a metal pipe or conduit shall not be used as a sole earth-continuity conductor, though it may be used to supplement a separate earth-continuity conductor.

11.8.3 Earthing in Agricultural Locations

11.8.3.1 The earthing lead of an agricultural installation shall be adequately protected against disturbance or damage by livestock or by mobile mechanical implements. Where the earthing lead is not enclosed in conduit or equivalent mechanical protection, it shall be of the armoured type.

11.8.3.2 Protection against earth-leakage currents by isolation of metal-work, as provided for in items (a), (e), and (f) of Clause 11.2.1, is not recognized for agricultural and horticultural installations, unless the metalwork is out of reach of livestock and is not liable to accidental contact with passing machinery, implements or vehicles.

11.9 Earthing in Industrial Premises

11.9.1 Connection with earth Terminals

All power-house and substation switchboards shall be provided with at least two different and independent earth connections, connected in parallel, to which all metal frames, all metal instrument cases (unless otherwise protected) and other metal parts thereof shall be connected. Means shall be provided to test the earth electrode resistance of these earth connections individually.

11.9.2 Metalwork (other than current-carrying parts) and one point of the secondary winding shall be connected to the appropriate earth-continuity conductor, provided that these Regulations shall not apply to–

a. A transformer in which the windings are mounted on separate limbs of an earthed core or are separated by an earthed metallic screen; or
b. A double-insulated transformer; or
c. The secondary winding of a “high-reactance’ transformer serving solely to energise a tesla coil or the heating element of an electric discharge lamp;
d. The secondary winding of a transformer in a shaver supply unit; or
e. A transformer which is an integral part of an item of apparatus, where the apparatus as a whole is the subject of and complies with Nigerian Industrial Standards; or
f. a transformer used in welding installations designed in accordance with the requirements in Nigerian Industrial Standards and NCP 9.

11.9.3 Connections to earth

a. Earthing connections and earth electrodes shall be of copper or galvanized steel.
b. Stranded or circular earthing leads shall have a minimum copper equivalent cross-sectional area of not less than 16 mm squared.
c. Flat earthing leads shall have a minimum copper equivalent cross-sectional area of not less than 50 mm squared and a minimum thickness of 3 mm.
d. Earth electrodes shall be in the form of plates or rods of the following minimum sizes –

i. Copper plates: 300 mm x 300 mm x 3 mm thick;
ii. Galvanized steel plates: 300 mm x 300 mm x 3 mm thick;
iii. Copper rods: 16 mm diameter;
iv. Galvanized steel rods: 25 mm diameter.

e. Earthing leads shall he capable of carrying for a period of five seconds the full fault current of the system to which they would be subjected.
f. The earthing requirements in 11.9.3(a) to (e) shall be read in conjunction with the Nigerian Code of Practice on Earthing NCP 9.

11.9.4 Earthing in Construction Sites

Because of the difficulty of creating an equipotential zone in a construction site it is unlikely that the developer will be able to make full use of a Protective Multiple Earthing facility, but the supplier may provide a PME terminal to site offices. If the condition that it will not be used for general eathing purposes can be satisfied. Where the supply is at high voltage the developer will have to provide an earth connection for the neutral. In damp and rough condition of construction sites all equipment of construction has to be robust and regularly inspected and continual attention should be paid to the earthing arrangements and protective circuit generally.

11.9.5 Earthing in Mobile Sites

Permanent buildings on a caravan may be treated as if they are ordinary premises and may be supplied and protected by generally adopted method of earthing. And in accordance with the specification of NCP 9.

11.10 Stand-by Generator Installation

Generating plant shall be connected to earthing by connecting the frame of the generator, associated exposed conductive parts to a main earthing terminal. The earthing terminal or bar is connected to an independent earth electrode and, where appropriate to other earthing facilities associated with the installation. Further earthing requirement of earthing on generator shall be referred to NCP 9. It is recommended that the earth resistance should not exceed 2 ohms.

11.11 **System Earthing**

a. In medium voltage and low voltage alternating current systems the connection of circuit with earth shall be made in accordance with the Nigerian Standard Code of Practice on Earthing (NCP 9) and the following requirements-

i. the intermediate conductor of a medium or, low voltage three-wire single phase system, and the neutral conductor of a medium three-phase four-wire system, shall be earthed in multiple. That is, at the point of supply (the generating station, sub-station or transformer) every fifth pole and the terminal poles of the distribution line. The consumer's earth must not be connected to the neutral conductor.
ii. the resistance between any point of the intermediate or neutral conductor and earth shall not exceed 2 ohms.
iii. the neutral point of a medium voltage three-phase three-wire system shall be effectively earthed at the point of supply.

b. In high voltage three-phase alternating current systems, the connections of the circuit with earth shall be made in accordance with Clauses 11.11.1.

11.11.1 Star-connected systems with earthed neutral

a. The neutral point shall be earthed at the point of supply. - That is, the generator neutral point or the neutral point of the transformer secondary where change of voltage occurs - and it may be earthed at any other point, provided that no interference of any description is caused by such earthing.
b. In the event of an appreciable harmonic current flowing in neutral connection such as to cause interference with communication circuits generator or transformer neutral shall not be earthed, but a suitable earthing transformer shall he used.
c. In unattended generating stations or sub-stations supplying overhead lines earth leakage relays shall be provided, so that in the event of a leak earth occurring either the faulty line will be cut out or the whole of the system supplied from this station or sub-station rendered dead.
d. These leakage relays if connected to individual feeders or lines shall be set to operate with a time lag not exceeding five seconds with a current exceeding ten per cent of the full load rating of the feeder or line, or, connected between the neutral point of the generator or transformer and earth at a current not exceeding one ampere.
e. Where under any conditions the use of earth leakage relays may be impracticable such relays may, with the written consent of the NERC be omitted: (it is suggested that additional devices be considered).
f. In continuously attended generating stations or sub-stations a visual and audible indication may be used to supplement the automatic disconnect of supply. In each case, immediate steps shall be taken to remove the fault and disconnect the faulty feeder or line.

11.11.2 Delta-connected systems or star-connected systems with isolated neutrals

a. In the case of delta connected systems or star-connected system with isolated neutrals earthing transformers or other means approved by NERC shall be provided to give an artificial, neutral point which shall be earthed. Earthing equipment shall be of sufficient capacity to ensure the effective operation of the protective apparatus;

simple leakage protection or indication shall be provided for these systems as specified in 11.11.1(c) and 11.11.1(f) for systems with earthed neutrals.

b. High Voltage single-phase systems derived from Delta or Star connected systems shall be earthed in a manner approved by NERC.
c. Where any part of supply system other than on a consumer premises, is normally connected with earth, no switch, fuse, or circuit-breaker shall be Inserted in the earthed conductor or in any conductor connected there and the connection with earth, shall be efficiently maintained except when interrupted for the purpose of periodical tests.
d. Notwithstanding anything contained in the last preceding Clause, systems including more than one generator operating in parallel may have the neutral conductor of a three-phase star-connected generator disconnected when necessary to prevent the circulation of local currents provided that where all the generators are located in one powerhouse, at least one generator in operation shall have its neutral point connected to earth: provided further that where the generators are contained in more than one powerhouse, and the powerhouses are inter-connected, a neutral point shall be provided at each power house and earthed and all such neutral points shall be so arranged that no earthed- circulating current will flow between the power stations.
e. When the return current of any individual distribution transformer does not exceed two amperes, and the transformer supplying the lines and any distribution transformer supplied by such lines are not less than 10 km from any telephone exchange, the earth may, with the previous consent in writing of the Telephone Operator, be used to carry the return current of the distribution transformers.
f. If the insulation of any circuit of any system is faulty, immediate steps shall be taken to make good the insulation before the current is again placed in service.

11.12 Steel Poles and Street Lighting Columns

11.12.1 Steel Poles

Where an un-energised steel pole or structure is erected either as tower or for a purpose arrangement shall be made to protect such structure from the effect of lightning strike by the provision of protective earthing.

11.12.2 Street Lighting and Street Furniture

Street furniture includes permanently site lighting columns, illuminated traffic signs, billboards and other electrically supplied equipment.

Class I Construction, in which exposed conductive parts are connected to the earthing terminal within the equipment.

Class II Construction, in which no provision is made for connection of exposed metallic parts of the street furniture to earth with this form of construction, care should be taken to ensure that any protective or PEN conductor in the supply cable has an insulated termination preventing contact with or connection to the metallic parts of the street furniture.

11.13 Tower Earthing

All towers shall be effectively earthed. The footing resistance of all towers shall be measured by the Transmission Service Provider (TSP) in dry weather after completing tower erection; but before stringing of earth wire. Tower footing resistance shall not exceed 2.0 Ohms. In areas of high resistivity counterpoise system shall be used.

11.14 Equipment Earthing

11.14.1 The minimum earthing design requirement for equipment shall take the following into consideration:

a. The reduction in risk to persons during the transfer of fault energy and load imbalance conditions,
b. The protection of equipment to operate satisfactorily under normal HV, MV, LV fault conditions,
c. Minimize the risk of voltage stresses in excess of the equipment Basic Impulse Level (BIL),
d. Meet the basic earthing value for;

Transmission Substations	≤ 1.0 Ω
Tower footing resistance	≤ 2.0 Ω

11.14.2 Substation earthing shall be done for the purpose of connecting neutral point of transformers, station auxiliary generators and non-current carrying metal parts, such as structures, overhead shielding wires, tanks, frames to the earth mat so that Touch and Step potentials within the Substation are in accordance with the relevant NCP on Earthing.

Chapter 12: Generation

12.1 Site Requirements

12.1.1 Site Approval

a. The applicant shall before siting and commencement of construction of Power Plant first obtain approval of the site from relevant government agencies and consent of the host community.
b. The applicant shall have a resettlement action plan (RAP) in case of involuntary resettlement and/or displacement of the host community or project affected Persons (PAP) where applicable.

12.1.2 Documentation

Every application for generation site approval by a licensee shall be accompanied by the following documentation:

a. A topographic map in 1-10,000 of the project sites
b. Geotechnical Investigations report
c. Site Layout plan
d. , EIA report

12.1.3 Geotechnical Investigations

a. Generation Licensee shall submit a detailed Geo-investigation of the site detailing its geology and geomorphology.
b. The generation site shall not be close to any known geological faults and the site shall have a 50-year history of lack of seismic activity.

12.1.4 Hydrology

A Generation Licensee shall submit a detailed hydrological report to indicate that the site will not be a subject of seasonal floods.

12.1.5 Water Permit

A water permit shall be obtained from the Federal Inland Waterways if the water is to be abstracted from inland water bodies for water use above 1000m^3 per day before;

a. commencement of construction work on new power plants;
b. any major generation capacity expansion work commences either through installation of additional units or higher capacity generating units.

12.1.6 Environmental Impact Assessment (EIA)

Before commencement of work on a new power plant or major rehabilitation of an existing power plant; generation Licensee shall therefore submit to the Commission an Environmental Impact Assessment Studies approved by the Federal Ministry of Environment indicating that all environmental issues likely to arise from the construction of the plant have been addressed and approval obtained.

12.1.7. Hydro-electric generation

a. Any applicant intending to set-up a mini hydro generating plant (1MW - 10MW) shall in addition to full compliance with sub-sections 12.1.1, 12.1.2, 12.1.3, 12.1.4, 12.1.5 and 12.1.6, shall prepare and submit to the Commission a scheme detailing the prospects for the best ultimate development of the river or its tributaries for power generation consistent with the requirements of drinking water, irrigation, navigation, flood control or other public purposes.

b. The Commission shall before concurring to any scheme submitted to it under sub-section 12.1.7(a), liaise with all relevant Government departments/agencies responsible for water resources management or such other agencies as it may deem appropriate and have particular regard to, whether or not in its opinion;

i. the proposed river-works will prejudice the prospects for the best ultimate development of the river or its tributaries for power generation consistent with the requirements of downstream users or other public purposes;

ii. an adequate study has been made of the optimum location of dams and other river works; and

iii. the proposed scheme meets the norms regarding dam design and safety.

c. Where a multi-purpose scheme for the development of any river in any part of the country is in operation, the Licensee shall liase with relevant Government agencies to ensure optimal integrated services.

12.1.8. ***Captive Generation***

a. Any user or Licensee in the electricity industry before siting and commencement of construction of captive power plant (self-power generation exceeding 1MW) shall comply with all relevant sections of the Commission's Captive Power Generation Regulations 2008

b. A generation licensee, may construct, own, maintain or operate a captive generating plant and dedicated distribution lines: provided that the supply of electricity from the captive generating plant through such lines shall be regulated in the same manner as applicable to grid operations.

c. Every licensee who has constructed a captive generating plant, maintains and operates such plant, shall have the right to open access for the purposes of supplying electricity from its captive generating plant to the destination of use:

i. provided that such open access shall be subject to availability of adequate transmission facility and such availability of transmission facility shall be determined by the TCN;

ii. provided further that any dispute regarding availability of transmission facility shall be adjudicated upon by the Commission.

d. A generation licensee can apply for sale of excess power (above 1MW) from the captive generation plant and subject to the Commission's approval.

e. All generation licensee shall submit technical details regarding its captive generating plant to the Commission.

12.1.9 ***Generation under Extraordinary Circumstances***

a. The Federal Government through the Commission may specify that a generation licensee shall, in extraordinary circumstances such as threat to security of the State, public order or a natural calamity or such other circumstances arising in the public interest; operate and maintain any generating station in accordance with the directions of the government.

b. The Federal government through the Commission shall offset the adverse financial impact of the directions referred to in sub-section 12.1.9(a) on any generation licensee in such manner as it conforms to the existing tariff regime.

12.2 Plant Design

12.2.1 General Provisions

a. General Design Considerations

   Licensee (s) and/or Generation Companies shall submit to the Commission a detailed engineering design of the power station based on applicable National and International Engineering codes. The design will ensure that the Power plant when built is able to generate its design capacity in a cost effective, reliable and safe manner with minimal impact on the environment.

b. Plant Layout
   Power plant arrangement will permit reasonable access for operation and maintenance of equipment. Careful attention shall be given to the arrangement of equipment, valves, mechanical specialties, and electrical devices so that rotors, tube bundles, inner valves, top works, strainers, contactors, relays, and like items can be maintained or replaced safely if and when necessary. Adequate platforms, stairs, handrails, and kickplates shall be provided so that operators and maintenance personnel can function conveniently and safely

12.2.2 Fuel Handling

a. **Fuel Source**
The type and availability to be indicated taking into account environmental regulatory requirements that may affect fuel and fuel characteristics of the plant.

b. **Stack emissions**
Electric power plant is to be designed with the type of stack gas cleanup equipment which meets both Federal (Nigerian Environmental Standards and Regulatory Agency – NESREA) and state emission requirements. For a solid fuel fired boiler, this may involve an electrostatic precipitator or bag house for particulate, and a scrubber for sulphur compounds unless fluidized bed combustion is employed. Boiler design will be specified.

c. **Waste Disposal**
For electric generating stations utilizing solid fuel, both solid and liquid wastes will be handled and disposed off in an environmentally acceptable manner. The wastes can be categorized generally as follows:

i. *Solid wastes.* These include both bottom ash and fly ash from boilers.
ii. *Liquid wastes.* These include boiler blowdown, cooling tower blowdown, acid and caustic water treating wastes, coal pile runoff, and various contaminated wastes from chemical storage areas, sanitary sewage and yard areas.

d. **Other Environmental Considerations:**
Other environmental considerations include noise control and aesthetic treatment of the project. The final location of the project within the site area will be decided taking into consideration its proximity to any nearby hospitals, schools, offices and residential areas. Also, the general architectural design will be reviewed in terms of coordination and blending with the style of surrounding buildings.

12.2.3 Technical Documentation

a. Applicants shall submit the following technical documentation to NERC for approval for the issuance of a construction permit
   i. Site Survey Plan
   ii. Soil Investigations
   iii. EIA
   iv. Site Layout Plan
   v. Listing and Specifications of major equipment
   vi. Construction Plan

b. Construction schedule including Engineering Drawings
c. Environmental Health and Safety Plan for Construction
d. Layout of Workers camp

12.3 Construction of Power Plants

12.3.1 Responsibilities of the Licensee or Contractor

Licensee/Contractor shall:

a. Comply with all applicable sections of the Nigeria National Building Code as well as Federal, State and Local Government Building and Environmental Health and Safety Regulations and procedures.
b. Ensure that all workers are fully qualified and/or certified with respect to mandated Environmental Health and Safety training as required by legislation and the relevant Codes and Regulations;
c. Provide Environmental Health and Safety documentation required under this Regulations to the Project Manager;
d. Provide all necessary Environmental Health and Safety equipment, including Personal Protection Equipment, as required for safe execution of work;
e. Comply with the Environmental Health and Safety Regulations and Directives Performance Requirements for Power Stations given by the Commission;
f. Record and report all incidents, injuries and accidents to the Environmental Health and Safety Coordinator within 24 hours of the accident/incident;
g. Stop work if the conditions are such that work cannot be performed safely;

12.3.2 Responsibilities of the Project Manager

a. The Project Manager shall prior to the commencement of the works, review the Environmental Health and Safety Management Plan prepared by the Contractor, and ensure that the Contractor has prepared an appropriate site-specific Environmental Health and Safety plan.
b. The Project Manager shall ensure that the Contractor has:
   1. Performed Hazard Assessment (Job Hazard Analysis) : and
   2. formulated prevention and control measures to address the identified hazards.
c. The equipment to perform the works safely;
d. Identified employees with the requisite knowledge and skills to perform the work safely;
e. An understanding of the obligation to comply with the applicable Occupational Health and Safety and Regulations, Codes and the relevant Environmental. Health and Safety procedures;
f. A plan and schedule for Environmental Health and Safety inspections of the contract site;
g. A plan for, and review of, ongoing recording of Environmental Health and Safety related events and incidents;
h. A plan and review of ongoing Environmental Health and Safety performance measurement activities; and
i. On site First Aid facilities, including but not limited to the administration of treatment and emergency evacuation where necessary.

12.3.3 Pre-Requisites for Commencement Of Construction

Before the commencement of construction work on new power plants or rehabilitation of an existing plant, the Licensee shall

provide to the Commission, a written copy of their up-to-date Environmental Health and Safety Program which shall include the following:

a. A signature by the Licensee or Applicant or by the person or persons responsible for the management of the company;

b. A statement of the Licensee or Applicant's commitment to cooperate with the Environmental Health and Safety Committee and workers in the workplace in carrying out their collective responsibility for the Environment, Health and Safety;

c. A statement indicating the respective responsibilities of the Licensee or Applicant, the contractor, supervisors, the Environmental Health and Safety Committee and workers in carrying out their collective responsibility for the Environment, Health and Safety;

d. Procedure to identify the need for, and for the preparation of, written work procedures to implement Environmental Health and Safety practices, including practices required by the Act and other relevant Regulations;

e. A plan for orientation and training of workers and supervisors in workplace and job-specific safe work practices, plans, policies and procedures, including for emergency response, that is necessary to eliminate, reduce, or control hazards;

f. Procedure and process for issuing and cancelling work permits;

g. Provision for establishing and operating an Environmental Health and Safety committee;

h. A system for the recognition, evaluation, and control of hazards that includes a means of evaluation and monitoring of the workplace to identify potential hazards and the associated risks; procedures and schedules for regular inspections by management and committee members; procedures for the identification, reporting, and control or correction of hazards; and procedures for the prompt investigation of hazardous occurrences to determine th e cause for the occurrence and the actions necessary to prevent a recurrence;

i. A plan for the control of biological, radioactive and chemical substances handled, used, stored, produced, or disposed of at the workplace;

j. An emergency response plan;

k. A provision for recording and maintenance of records and statistics, including Environmental Health and Safety Committee minutes, and reports of Environmental Health and Safety inspections and investigations;

l. A provision for monitoring the implementation and effectiveness of the program; and

m. A short Environmental Health and Safety induction exercise for all visitors.

12.3.4 Pre-Construction Site Meeting

A Pre-Construction meeting shall be conducted to review the requirements for Environmental Health and Safety, and shall include but not be limited to the following:

a. A review of the contract document clauses specific to Environment Health and Safety;

b. A review of Environmental Health and Safety procedures relevant to the contract;

c. Determination of the frequency and method of site Environmental Health and Safety inspections.

d. Determination of the duration and frequency of the Environmental Health and Safety meetings and Environmental Health and Safety talks.

e. A weekly ''Toolbox Meeting" shall be conducted for all contracts. The Agenda shall include, but not limited to the following:

i. Identification of specific risks and hazards associated with the contract work;

ii. Discussion of controls required to manage the risks and hazards identified

iii. Reporting and correcting of all Environmental Health and Safety deficiencies;

iv. Reporting of Environmental Health and Safety incidents and injuries;

v. Appointment of Contract Environmental Health and Safety representative, and

vi. Emergency procedures for the contract.

12.3.5 Environmental Health and Safety Induction

a. The Project Manager shall be responsible for organizing an Environmental Health and Safety induction before the contractor begins work.

b. The induction process shall be based on the critical nature of the work and shall specify the Environmental Health and Safety procedures and guidelines.

c. The Contractor's Induction Program shall be signed off by the Sponsor or nominated representative of the sponsor to confirm that the Induction Program is adequate and conforms to relevant standards on Environmental Health and Safety.

d. The Induction program shall discuss Environmental Health and Safety Issues which shall include but not be limited to the following subjects:

i. Contractor/Employee Induction Quick Reference Card containing Contractor guidelines.

ii. Site entry and Access

iii. Care of the Environment

iv. Work permits and cancellation

v. Safe Working Practices

vi. Working from Heights

vii. Confined Spaces

viii. Manual handling and materials movement

ix. Hazardous substances

x. Plant and Equipment

xi. Health and Safety devices

xii. Personal protective clothing

xiii. Housekeeping

xiv. Waste disposal

xv. Incident/Emergency Response

xvi. Fire protection

xvii. First Aid

xviii. Isolation of services

12.3.6 Site Health and Safety Plan

Contractors undertaking work in electric power stations are required to prepare a site Health and Safety Plan for each contract specific to the risk that will or may be encountered during the execution of the contract.

12.3.6.1 Issues for Site Health and Safety Plan

The following is a list, non-limiting, of issues that may apply to a contract for the construction of new plants or rehabilitation of existing plants. Where the issue is relevant to the contract, the safe work practice to be used by the contractor should be outlined in the Health and Safety Management Plan, along with the documentation to demonstrate employees are trained in the procedures.

The following are possible issues:

a. Lockout/ Tagout
b. Excavation/Trenching procedures
c. Confined Space Entry
d. Forklift Driver Health and Safety
e. Hot Work Permits and Cancellation
f. Emergency Response and evacuation
g. Ladders, Platforms, Scaffolds and Lifts
h. Site Isolation
i. Fall Protection
j. Waste Disposal procedures
k. Personnel Health and Safety
l. Back injury prevention
m. Site Housekeeping
n. Laboratory Health and Safety
o. Vehicle access to site
p. Electrical equipment grounding
q. Emergency exit from site
r. Asbestos
s. Smoking
t. Fire protection
u. Personal Protective Equipment
v. Hearing and Sight Conservation
w. First Aid
x. Signage of Work place, equipment and tools

y. Chemical/Material handling

z. Machine guarding

aa. Waste management

12.3.7 Water Management

The use of water during construction and operation of power plants shall comply with the provisions of the National Guidelines and Standards for Water Quality in Nigeria (1999), which provides for the proper management of water (either marine or interstate fresh water) to maintain its quality as prescribed hereunder (Table 12.3.7)

Table 12.3.7:

Water Quality Standard for Thermal Power Generation Station
Concentration (mg/l) Cooling Once Through

Parameter	Fresh	Brackish*	Boiler Feedwater	Misc. Uses
Silica	<50	<25	<0.21	-
Aluminium	NS	NS	<0.01	-
Iron	NS	NS	<0.01	<1.0
Manganese	NS	NS	<0.01	-
Calcium	<200	<420	<0.01	-
Mangnesium	NS	NS	<0.01	-
Ammonia	NS	NS	<0.07	-
Bicarbonate	<600	<140	<0.5	-
Sulphate	<680	<2700	NS	-
Chloride	<600	<19000	NS	-
Dissolved solids	<1000	<35000	<0.5	1000
Copper	NS	NS	<0.01	-
Hardness	<850	<6260	<0.07	-
Zinc	NS	NS	<0.01	-
Alkalinity (as $CaCo_3$)	500	<115	<1	-
pH unit	5.0-8.3	6.0-8.3	8.8-9.4	5.0-9.0
Organic material Methylene blue active substances	NS	NS	<0.1	<10
Carbon tetrachloride extract	<NS	NS	NS	<10
Chemical Oxygen Demand (COD)	<75	<75	<1.0	-
Dissolved oxygen	-	-	<0.007	-
Total suspended solids	<500	<2500	<0.05	<5

Note:
* = *Brackish water- dissolved solids more than 1000 mg/l*
NS = No Specification
Source: Guidelines and Standards for Environmental Protection in Nigeria, 1991

12.3.8 Emission and Effluent Discharge Limitations

The National Guidelines and Standards for Environmental Control impose among, other restrictions, the release of toxic substances during the construction and operation of power plants. It also stipulates requirements for monitoring of pollution to ensure that permissible limits are not exceeded. The Statutory Guidelines provide limits for the emissions of GHGs, pollutants and particulates.

12.3.8.1. Particulates

a. Particulate matter (PM)

Table 12.3.8.1a below specifies the National emission limits for particulates from combustion of various fuels.

For all Power plants or units, PM emissions (all sizes) during construction shall not exceed 500 mg/m^3.

Table 12.3.8.1a

Emission Limits for Air Particulates from Stationary Sources

Combustion of Fuel	**Limits (mg/m^3)**
Coal	500
Oil	250
Heavy Oil	300
Natural Gas	NS

NS: Not Specified

Source: Guidelines and Standards for Environmental Protection in Nigeria, 1991

b. Atmospheric Pollutants (See Table 12.3.8.1b)

i. *Sulphur Dioxide.* Total sulphur dioxide emissions during construction shall not exceed 830 µg/m^3.

ii. *Nitrogen oxides.* The specific emissions of nitrogen oxides shall not exceed 500 µg/m^3 during construction.

iii. *Carbon Monoxide:* Emissions of carbon monoxide during construction shall not exceed 5000 µg/m^3.

iv. *Volatile Organic Carbon (VOC):* Total emissions of VOC during construction shall not exceed *6000* µg/m^3.

Table 12.3.8.1b:

Emission Limits for Gaseous Pollutants

Parameter	**Emission Standard µg/m^3**
Particulates	500
SO_2	830
NO_x	500
CO	5000
H_2S	30
VOC	6000

Source: Guidelines and Standards for Environmental Protection in Nigeria, 1991

c. Liquid Effluent

i. Effluent discharged during construction shall comply with the National effluent discharge guideline for discharge of effluent to land and inland water see Table 12.3.8.1c

Table 12.3.8.1c

Interim Effluent Limitation Guidelines ini Nigeria

Parameters	**mg/l**	
	Limit for discharge into surface water	**Limit for Land application**
Temperature	Less than 40ºC within meter of outfit	Less than 40º C
Colour (Lovibond Units)	7	-
pH	06-Sep	06-Sep
BOD5 at 20ºC	50	500
Total suspended solids	30	-
Total dissolved solids	2000	2000
Chloride (as CI-)	600	600
Sulphate (as SO42-)	500	1000
Sulphide as S2-	0.2	-
Cyanide (as CN-)	0.1	-
Detergents (linear alkyl sulphonate as methylene blue active substance)	15	15
Oil and grease	10	30
Nitrate (as NO3)NO3	20	-
Phosphate (a PO43	5	10
Arsenic (as As)	0.1	-
Barium (as Ba)	5	5
Tin (as Sn)	10	10
Iron (as Fe)	20	-
Manganese (as Mn)	5	-
Phenolic compounds (as phenol	0.2	-
Chlorine (free)	0.1	-
Cadmium Cd	< 1	-
Chromium (trivalent and hexavelant)	< 1	-
Copper	Less than 1	-
Lead	less than 1	-
Mercury	0.05	-
Nickel	Less than 1	-
Selenium	Less than 1	-
Silver	0.1	-

Zinc	Less than 1	-
Total metals	3	-
Calcium (as Ca2+)	200	-
Magnesium(as Mg2+)	200	-
Boron (as B)	5	5
Alkyl mercury compounds	Not dectectable	-
Polychlorinated Biphenyl	0.003	0.003

12.3.8.2. Also, thermal power plants shall comply during construction with the guidelines listed in Table 12.3.8.2

Table 12.3.8.2

Effluent Limitations for Thermal Power Plants

Parameter	Value
pH	6 – 9
Total Suspended Solids	50 mg/l
Oil and Grease	10 mg/l
Chromium (total)	0.5 mg/l
Total Residual Chlorine	0.2 mg/l
Copper	0.5 mg/l
Iron	1.0 mg/l
Zinc	1.0 mg/l
Polychlorinated Biphenyl (PCB)	0.003 mg/l
Mercury	0.05 mg/l
Temperature Increase	3 ^oC

Source: Pollution Prevention and Abatement Handbook, World Bank, 1998

12.3.9 Solid Wastes

During construction, solid wastes that do not leach toxic substances or other contaminants of concern to the environment may be disposed in landfills or other disposal sites provided that they do not impact nearby water bodies. Where toxics or other contaminants are expected to leach out, they should be treated by, for example, stabilization before disposal.

12.3.10 Ambient Noise

Noise during construction shall be limited to levels indicated in Tables 12.3.10a. Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

Table 12.3.10a

Maximum Permissible Noise Levels During Construction

Noise Control Zone	Sound Level dB (A) (Leq)	Sound Level dB (A) Leq
	Day	Night
Residential	60	40
Commercial	75	50
Industrial	85	65
Time Frame: Day: 6.00 a.m. – 10.00 p.m. Night: 10.00 p.m. – 6.00 a.m. The time frame takes into consideration human activity.		

Source: The National Environment (Noise Standards and control) Regulations 2003

Table 12.3.10b

Maximum Permissible Noise Levels for Impact Noise

Sound Level dB (A) (L_{max})	Permitted Number of Impulses or Impacts per day
140	100

Source: The National Environment (Noise Standards and Control) Regulations 2003

The maximum permissible level for impact noise during construction is given in Table 12.3.10b above.

The noise level at receptors close to a Power Plant, at any time, shall not exceed the limits indicated in Table 12.3.10c.

Table 12.3.10c

Maximum Permissible Levels at nearby Receptors

Facility		Noise Limits B (A) (Leq)	
		DAY	NIGHT
A.	Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites.	45	35
B.	Residential buildings	50	35
C.	Mixed residential (with some commercial and entertainment)	55	45

D.	Residential + industry or small-scale production = commerce	60	50
E.	Industrial	70	60
Time Frame use duration Day: 6.00 a.m. – 10.00 p.m. Night: 10.00 p.m. – 6.00 a.m. The time frame takes into consideration human activity.			

Source: The National Environment (Noise Standards and control) Regulations 2003

12.3.11 Record Keeping

The following information shall be kept during construction.

a. Site-specific Health and Safety Plan, and criteria used to approve the plan

b. Minutes of Health and Safety start-up meetings

c. Contract Health and Safety evaluation

d. Stop Work orders

e. Accident and injury reports

f. Site-specific workplace inspection reports

12.4 Power Evacuation

12.4.1 Voltage Levels:

The Generator shall ensure that the nominal and operational voltages sent to the transmission System are 132kV and 330kV depending on the plant.

12.4.2 Voltage Variations:

The Generator shall maintain the output voltage sent out to the grid to be within the voltage control ranges specified in the Grid Code, Part 3, Section 2.1 as amended as specified in Table 12.4.2

Table 12.4.2

Generated Nominal Terminal Voltage

Nominal Voltage Level	Minimum Voltage	Maximum Voltage	Range %
330KV	313.5 (0.95) kV	346.5 (1.05) kV	+/- 5%
132kV	118.8 (0.9) kV	143.0 (1.09) kV	+/- 10%

12.4.3 Frequency Level:

All Generators shall operate at a nominal 50 Hz frequency mode but shall be able to remain in operation for system frequency deviations with reasonable deviations from the nominal, in order to prevent unnecessary system shutdowns whenever the system frequency varies from the nominal even for minor values.

12.4.4 Frequency Variations:

a. Generators shall ensure that the output frequency of the station is maintained reliably and safely within the limits specified in the Grid Code Part 3, Section 2 as amended such that under extreme system fault conditions all generating units should disconnect at frequencies greater than or equal to 51.75Hz, and less than or equal to 48.5Hz, via over frequency and under frequency relays respectively, unless agreed otherwise in writing with the System Operator.

12.4.5 Generators shall allow only tolerable small amounts of harmonics such that the Total Harmonic Distortion (THD) is limited to ≤ 20%*[as stipulated in the Grid Code] Technical Criteria for Plant and Apparatus at the Inter - Connection Point

a. Generator Installations:

Technical facilities must be installed on all Generator networks to provide the following information to the responsible Control Centre:

i. Status indications of circuit breaker, isolator switches, and earth switches in so far as they are required for operation of the network.
ii. Measurement of Active and Reactive power flow in both import and export directions, as well as voltages and frequency.
iii. Where applicable, reference values for control (activation/deactivation of primary/ secondary control) and instantaneous Demand value of the secondary control.
iv. Reference value of the Reactive Power in the form of the schedule or as an instantaneous value (e.g. for voltage and Reactive Power control).
v. Critical protection information.

b. Generator Control Centre:

c. The control centre of each Generator shall provide the facilities to effectively schedule the power interchange with the control centre of the interconnected network.

12.4.6 Performance Requirements for Power Stations:

a. The generating units shall have, at least, the following requirements:

i. Each Generating Unit must be capable of supplying rated power output (MW) at any point between the limits of 0.85 power factor lagging and 0.95 power factor leading, at the Generating Unit terminals at rated voltage level in the Transmission Network.
ii. Each Generating Unit must be capable of continually supplying its registered output within the power system frequency range of 50Hz ±0.5%. Under system stress the frequency variations within the limits of 50Hz ± 2.5% (48.75 - 51.25Hz).
iii. Under extreme system fault conditions all Generating Units should disconnect at the following frequencies:

a. By a frequency greater than or equal to 51.75Hz (+3.5%)
b. By a frequency less than or equal to 48.5Hz (-3.0%).

iv. The active power output under steady state conditions of any Generating Unit directly connected to the transmission network should not be affected by voltage changes in the normal operating range. The Reactive Power output of a Generating Unit having a synchronous alternator must, under steady state conditions, be fully available within the voltage range ± 10% of nominal voltage at the connection point.

v. A Generating Unit having a synchronous alternator must be capable of start up, synchronize and pick up load:
a. From cold, within 10 hours
b. From warm, within 6 hours
c. From hot, within 15 minutes.

vi. A steam – turbine or gas – turbine Generating Unit which has been synchronized must be capable of ramping up pursuant to a Dispatch instruction at a rate of at least 3% Gas cooling rate (GCR) per minute. A steam – turbine or gas – turbine Generating Unit must be capable of de-loading at a rate of at least 3% Gas cooling rate (GCR) per minute.
b. Power Producers shall be responsible for protecting all their Generating Units against damage should system frequency variations exceed 51.5Hz or go below 47.5Hz. In the event that such variations occur, the Power Producer shall disconnect the Generating Unit for reasons of safety of personnel, apparatus, and/or plant.

Electrical protection of the Generating Unit shall take precedence over operational controls (e.g. voltage controllers, excitation equipment) and the Generating Unit shall disconnect from the network should unacceptable Operational States arise as a result of failure of the operational controls. This shall apply in particular when spontaneous faults occur (e.g. earth faults, short circuits).

c. All Power Stations shall meet the performance requirements as contained in Part 3 Section 4 of the Grid Code in respect of Turbine Controllers and Automatic Voltage Regulators.

Chapter 13: Renewable Energy

13.1 General

This standard covers renewable energy sources, as provided in the Electricity Act, 2023.

All the general requirements of power generation contain in chapter 12, sections 12.1, 12.2, 12.3 and 12.4 of this regulation shall be applicable here, in addition to specific requirement for renewable energy-based power plant.

13.2 PHOTOVOLTAIC (PV) SYSTEMS

This regulation shall apply to a grid-connected PV system comprising multiple PV arrays interconnected directly to the 330kV, 132kV, 33kV and 11kV networks and standalone PV system. The minimum generation capacity of 50MW, 20MW shall apply for intermittent sources connected to 330kV and 132kV respectively, while that of 33kV and 11kV networks shall be below 20MW. For connection of non-intermittent sources, the conditions for connection in the grid code and distribution code shall apply.

13.2.1 SCOPE

This covers ground mounted and rooftop array configurations, battery energy storage systems, Inverters, and other balance of system equipment (cable routing methods, cable selection, overcurrent protection strategies, equipotential bonding over large geographical areas, and equipment considerations), as provided in NIS IEC 62738.

13.2.2 PV System Design

Design requirements for PV arrays including DC array wiring, electrical protection devices, switching and earthing provisions shall be in accordance with the provisions of NIS IEC 60364, NIS IEC 62109-1and NISIEC 62109-2

13.2.3 Site Specific Design Requirements

An applicant in addition to full compliance with the provisions of section 12.1.2, shall submit to the Commission for approval the following:

i. Architectural/Engineering design, showing available space for the proposed project before commencement of construction work at the site.
ii. the detailed engineering drawing showing the proposed location and layout for both PV panels and inverter(s) as provided by the relevant professional Engineer.
iii. The layout in subsection ii above shall address equipment protection from falling objects and provision of walkways.
iv. The engineering design shall include a single-line electrical diagram for the PV

system, symbols, legends, equipment specifications and interface requirements for grid connections.

v. Any alteration to the original engineering design during project implementation shall be communicated to the Commission.

vi. The design, erection and output capacity verification of the PV system shall comply with the requirements of, NIS/IEC 60364-1, NIS/IEC 60364-4 (all parts), NIS/IEC 60364-5 (all parts), and NIS/IEC 60364-6

vii. PV arrays shall comply with the safety requirements as contained in NIS IEC 62109-1 and NIS IEC 62109-2 standards.

13.2.4 PV Arrays Design and Installation Specifications

All PV arrays for deployment shall comply with the requirements as contained in NIS/IEC 62109-1, NIS/IEC 62109-2 safety requirement standards, NIS/IEC 62548 design requirements for PV arrays, IEC 61225 and IEC 61646 design qualification and type approval requirements in addition to the following minimum technical requirements.

13.2.4.1 Mechanical Design

Support structures and module mounting arrangements shall comply with applicable building codes regulations and standards and module manufacturer's mounting requirements. Variations to these requirements for large-scale ground mounted PV power plant shall be in accordance with NIS/IEC TS 62738 and NIS/IEC 61730 standards on PV module safety qualifications, requirements for construction and testing in addition to the following minimum technical requirements.

i. The tilt angle of PV module installation should be $\leq 15^o$.

ii. When the solar module is facing the south, the Azimuth (orientation) angle should be 180^o

iii. The PV module Clips should be properly installed (not covering part of the solar cell) to the edge of PV module.

13.2.4.2 Mechanical Loads on PV structure

The PV array support structures shall comply with national standards, industry standards and provisions on mechanical loads on PV structure as contained in NIS/IEC 62548 and NIS/IEC 62738 standards. Consideration shall be given to site drainage and, in areas where the ground freezes, the freeze-thaw characteristics of the soil shall also be considered.

13.2.4.3 Combiner Box

Specifications, safety, and installation of combiner box shall be as contained in the provisions of NIS/IEC 62548 and 62738.

13.2.4.4 Charger Controller

Charger controller installation shall be in accordance with the relevant provisions of NIS IEC 60227, NIS IEC 69947, NIS IEC62405 and NIS IEC 62257-9 standards in addition to the following requirements,

i. Open circuit voltage (V**oc**) and short-circuit current (I**sc**) of photovoltaic strings should be less than the specification of solar charge controller input.
ii. The minimum distance between installed two or more charge controllers should not be less than 15cm (0.15m).

13.2.4.5 PV Converters (Inverter)

The specifications and number of inverters shall comply with design reference document, provisions of NIS IEC 62109-1, IEC 62109-2 standards on safety of power converters and general requirements for use in PV power systems, NIS IEC 61727 characteristics of the utility interface and NIS IEC 62116 requirements on utility-interconnected PV inverters.

13.2.4.6 Battery Requirements

A. Provision of Battery Specification Sheets

i. A battery specification sheet from the battery manufacturer, showing a minimum acceptable deep discharge protection and overcharge protection thresholds, shall be provided for all batteries.
ii. Additionally, companies shall declare the battery chemistry and provide a safety data sheet (SDS) or similar documentation to support the declaration for all batteries in the system.
iii. For lithium-based batteries, the declaration of the chemistry shall state the specific materials used, such as "lithium cobalt oxide" or "lithium iron phosphate." A generic term such as "lithium-ion" is not sufficient.

B. Safety Standards

All lithium batteries, including those in appliances, shall meet the requirements of a standard for safety during use. Refer to sub clause 13.2.7 of this regulation.

C. Battery Durability

The batteries shall meet the battery durability requirement as contained in NIS/IEC TS 62257-9-5.

D. Exceptions

The following batteries need not meet the requirements of “battery durability” subsection above:

a. Flooded lead acid batteries that are shipped dry.

b. Lithium iron phosphate batteries that have been tested according to and meet the requirements of the type tests specified in IEC 61427-1, provided that the testing is conducted at a laboratory that has demonstrated competence, metrological traceability, and impartiality.

13.2.4.7 PV Battery Bank

PV battery bank arrangement and specification shall be as contained in NIS/IEC 62485-6, NIS IEC 62485-5, and NIS IEC 61427

13.2.4.7.1 Inverter Batteries

Inverter batteries specification and installation shall be as contained in NIS IEC 62116, NIS IEC 62109-1, NIS IEC 62109-2, NIS/IEC 62109-1, NIS/IEC 61727, and IEC 62257-9 standards.

13.2.4.7.2 Battery Charge Control

All batteries shall be protected by an appropriate charge controller that prolongs battery life and protects the safety of the user. All tested samples shall meet the requirements as outlined in the relevant clauses of NIS/IEC 62257-9-5.

13.3 Wiring Inspection

i. The conductors connecting the PV module to the main unit shall be sized to safely carry the maximum short circuit current of the module.
ii. The conductor diameter shall be measured using an appropriate instrument (e.g., callipers, micrometer, or wire gauge); for multi-stranded conductors, multiple measurements should be made to determine an average diameter for the bundle, or an individual strand may be measured and then the result multiplied by the number of strands.

13.4. PV System Protection

The requirements for PV system protection against overcurrent, thermal effects, overvoltage, earth fault, lightning and insulation faults shall be as contained in clauses 6.2, 6.3, 6.4, 6.5, and 6.6 of NIS IEC 62548:2016 and NIS IEC TS 62257-9-5

13.5. Commissioning Test

Module string or wiring harness, voltage and current tests shall be conducted during commissioning and baseline values are recorded for future comparisons in accordance with the requirements of clauses 6.4, 7.2, and sub-clause 6.5.3 of IEC 62446-1:2016

13.6. PV System Maintenance

All PV maintenance activities shall be in accordance with the maintenance procedures detailed in Clause 9 of NIS IEC 62446- 1:2016. The date, description of the activity, and any findings should be included in the record in compliance with NIS IEC 62446-2 on maintenance procedures. These records should be used for reference, trending of performance and corrective maintenance actions. Verification tasks, intervals, and triggers of maintenance activities at the system and component level shall be in accordance with Table 3 NIS IEC 62446-1: standard.

13.7. Training

a. The licensee shall maintain a training program that includes training identified to be critical to success, including familiarity with relevant sections of the technical documents described in Annex B of NIS IEC 63049
b. Additionally, Maintenance & Operations personnel shall be thoroughly trained by the installing PV Contractor and/or manufacturer on the following:
   i. System components
   ii. Maintenance
   iii. Troubleshooting
   iv. Monitoring
   v. Training shall be video-taped and coordinated with PV plant licensee owner's engineer.

13.8. Safety Requirements

All safety requirements concerning operations and maintenance of the PV system shall be in accordance with the procedures as contained in Annex E of NIS IEC 62446-2 and clause 6 of NIS IEC 62548:2016

13.9. Power Evacuation

PV power plant shall be connected to the power grid when the frequency and the voltage at the PCC conforms with the Grid code specification in Table 12.4.2 or otherwise stated in the Connection Agreement (CA) between the transmission service provider and the PV power plant owner.

13.10. Grid-Interactive Inverter

Grid-interactive inverters, also known as grid-tied inverters, are devices used in renewable energy systems, to convert direct current (DC) electricity generated into alternating current (AC) electricity fed into the electrical grid. These inverters must be designed to synchronize with the utility grid, ensuring that the electricity they produce is compatible with the grid's voltage and frequency.

13.10.1. General Testing Requirements

All compliance tests on grid-interactive inverters shall be carried out as contained in NIS IEC 62109-1 and clause 4 of NIS IEC 62109-2:2011.

13.10.2. Inverter Ratings

Ratings and markings of inverters to be used in the grid system shall be as contained in Table 32 of NIS IEC 62109-2:2011. Additional requirements for rating and marking of inverters shall be as contained in NIS IEC 62109-1 and clause 5 of NIS IEC 62109-2:2011.

13.10.3 Grid-Interactive Inverter Setpoints

Setpoints for grid interactive inverters shall follow sub clause 5.3.2.2 of NIS IEC 62109-2:2011 and the Grid Code rules on interconnectivity**.**

13.10 .4 Inverter Isolation Transformers

Inverter isolation transformers are specialized transformers used in conjunction with inverters in renewable energy systems to provide electrical isolation between the inverter and the grid or load. These transformers serve several important functions, including safety, noise reduction, and voltage matching.

Use of inverter isolation transformer shall meet the requirements of clauses 5.3.2.3 and 5.3.2.4 NIS IEC 62109-2:2011.

13.11 Technical Criteria for PV System and Apparatus at the Interconnection Point

13.11.1 PV System Installations

i. Technical facilities must be installed in the solar PV power plant networks to provide the following information to the responsible Control Centre:
ii. Status indications of circuit breaker, isolator switches, and earth switches in so far as they are required for operation of the network.
iii. Measurement of Active and Reactive power flow in both import and export directions, as well as voltages and frequency.
iv. Where applicable, reference values for control (activation/deactivation of primary/ secondary control) and instantaneous Demand value of the secondary control.
v. Reference value of the Reactive Power in the form of the schedule or as an instantaneous value (e.g. for voltage and Reactive Power control).

13.11.2 Performance Requirements for PV Systems

The PV systems shall have, at least, the following requirements:

i. A PV system must be capable of supplying rated power output (MW) at any point between the limits of 0.85 power factor lagging and 0.95 power factor leading, at the Generating Unit terminals at rated voltage level in the Transmission Network.
ii. PV system must be capable of continually supplying its registered output within the power system frequency range of 50Hz ±0.5%. Under system stress the frequency variations within the limits of 50Hz ± 2.5% (48.75 - 51.25Hz).
iii. Under extreme system fault conditions all PV system shall disconnect at the following frequencies as specified in section 10.1.4 of the Grid Code:

a. By a frequency greater than or equal to 51.75Hz (+3.5%)
b. By a frequency less than or equal to 47.5Hz (-3.0%).

iv. The active power output under steady state conditions of any PV generating unit directly connected to the transmission network should not be affected by voltage changes in the normal operating range.
v. The Reactive Power output of a PV generating unit must, under steady state conditions, be fully available within the voltage range ± 10% of nominal voltage at the connection point.
vi. Power Producers shall be responsible for protecting all their solar PV power plant against damage should system frequency variations exceed 51.5Hz or go below 47.5Hz. If such variations occur, the Power Producer shall disconnect the Generating Unit for reasons of safety of personnel, apparatus, and/or plant.
vii. Electrical protection of the solar PV power pack shall take precedence over operational controls (e.g., voltage controllers, excitation equipment) and the PV power plant shall disconnect from the network should unacceptable operational states arise as a result of failure of the operational controls. This shall apply in particular when spontaneous faults occur (e.g., earth faults, short circuits).

13.12 Stand-alone PV and Solar Home System

13.12.1 Scope

These standards outline the Standard Technical Requirements for the construction, connectivity to the grid and distribution network for sale of electricity generated from renewable energy sources to distribution and trading licensees, eligible customers and other consumers. This section aims to provide standards for solar homes systems and stand-alone PV system.

13.12.2 Stand-Alone PV system

This encompasses all components required to provide basic energy services which are sold/installed as a kit or integrated into a single component, including at a minimum:

i. A battery/batteries or other energy storage device(s)
ii. Power generating device, such as a solar panel, capable of charging the battery/batteries or other energy storage device(s)
iii. Cables, switches, wiring, connectors and protective devices sufficient to connect the power generating device, power control unit(s) and energy storage device(s)
iv. Loads (optional), such as lighting, load adapter cables (e.g., for mobile devices), and appliances (television, radio, fan, etc.).

13.12.2.1 Port requirements

These requirements apply to products that include output ports to power appliances or mobile devices shall follow NIS IEC TS 62257-9-5.

13.12.2.2 Appliance Voltage Compatibility Requirements

Voltage range of the port shall be as contained in the provisions of NIS IEC TS 62257-9-5 on DC ports.

13.12.2.3 AC-DC Power Supply Safety

i. Any included AC-DC power supply shall carry a recognised consumer electronics safety certification with accompanying valid documentation.
ii. A test certificate and/or test report shall be provided showing that the included AC-DC power supply has been tested against the appropriate safety standards and that the test results are current and valid.
iii. The certificate or report shall be prepared by a laboratory that has demonstrated competence, metrological traceability, and impartiality.

13.12.2.4 Hazardous Substances

Batteries shall not contain mercury or cadmium at levels greater than trace amounts (0.0005 % mercury and 0.002 % cadmium by weight).

13.12.2.5 Wiring and Connector Safety

i. All cables, wires and connectors shall be appropriately sized for the expected current and voltage, and all connectors and wire joints shall be robust.
ii. All external cords provided with the product shall be capable of carrying the electric currents present during normal operation without exceeding 50 °C ± 3 °C (measured at 25 °C ± 3 °C ambient temperature). This requirement is primarily assessed using a declaration from the manufacturer.

13.12.2.6. Physical Ingress Protection

All components that contain electronics or electrical connections shall meet the requirements in Table 3of NIS IEC TS 62257-9-5

13.12.2.7 Drop Test Requirements

All components advertised or designed to be used while carried shall pass the drop test described in NIS IEC TS 62257-9-5. Fixed-indoor components that are designed to be permanently secured are not subject to the drop test.

13.12.2.7.1 Switch, Gooseneck, Connector, and Moving Parts Durability

These tests shall be conducted according to the provisions of NIS/IEC TS 62257-9-5

13.12.2.7.2 Strain Relief Durability

All cables attached to any included component, e.g., PV module or light point, shall pass a strain relief test in accordance with NIS IEC TS 62257-9-5.

13.12.2.7.3 Outdoor Cable Durability

All included outdoor cables shall be outdoor-rated and UV resistant in accordance with NIS IEC TS 62257-9-8.

13.12.2.7.4 IP class/IP rating

This is the degree of protection provided by enclosures for electrical equipment against penetration by foreign bodies and dust/water. It shall be as defined in NIS IEC 60529.

13.13 Wind Turbine

13.13.1 Scope

This regulation shall apply to grid-connected wind turbine power plants interconnected directly to the 330kV, 132kV, 33kV and 11kV networks with a minimum generation capacity of 5MW and small wind turbine (SWT) power systems. It shall cover technical areas which include wind turbine, battery energy storage systems, Inverters, and other balance of system equipment (cable routing methods, cable selection, overcurrent protection strategies, equipotential bonding over large geographical areas, and equipment considerations), as contained in NIS IEC 61400.

13.13.2 Wind Turbine System Design

Design requirements for wind turbine including support structures, electrical protection devices, switching and earthing provisions shall be in accordance with the provisions of NIS/IEC 61400-1

13.13.2.1 Site Specific Design Requirements

An applicant in addition to full compliance with the provisions of section 12.1.2, shall submit to the Commission for approval the following:

i. Architectural/Engineering design, showing available space for the proposed project before commencement of construction work at the site.
ii. the detailed engineering drawing showing the proposed location and layout for both Wind turbine and inverters (if necessary) as provided by the manufacturer.
iii. The manufacturers shall provide an installation manual clearly describing installation requirements for the wind turbine structure and equipment.
iv. The engineering design shall include a single-line electrical diagram for the Wind turbine power system, symbols, legends, equipment specifications and interface requirements for grid connections.
v. Any alteration to the original engineering design during project implementation shall be communicated to the Commission.
vi. The design, erection and output capacity verification of the Wind Turbine Power System shall comply with the requirements of NIS/IEC 61400., NIS/IEC 60364-4 (all parts), NIS/IEC 60364-5 (all parts), and NIS/IEC 60364-6.

vii. The wind turbine power system shall comply with the safety requirements as contained in NIS/IEC 61400.

13.13.2.2 Wind Turbine Design and Installation Specifications

Wind turbine power plants deployment shall comply with the requirements as contained in NIS/IEC 61400-1 which specifies essential design requirements to ensure the structural integrity of wind turbines, safety requirement standards and design qualification and type approval requirements.

13.13.2.3 Structural Design

i. The integrity of the load-carrying components of the wind turbine structure shall be verified and an acceptable safety level shall be ascertained.
ii. The ultimate and fatigue strength of structural members shall be verified by calculations, tests, or both to demonstrate the structural integrity of a wind turbine with the appropriate safety level in line with NIS/IEC 61400-1.
iii. The structural analysis shall be based on NIS/IEC 61400-1.
iv. In general, a consideration of all load cases given in NIS/IEC 61400-1 or NIS/IEC 61400-2 shall be used for dimensioning.

13.13.2.4 Steel Towers

a. Structural Steels

Only structural steel that meets the requirements as contained in Annex B of NIS/IEC 61400-6 shall be used.

b. Bolts and Anchors

i. The material for bolts and anchors shall comply with the requirements stated in NIS/IEC 61400-1 or equivalent.
ii. Bolts bigger than those covered by NIS/IEC 61400-1 shall be derived rationally from those covered in the reference standard.
iii. For the bolts in the ring flange connections, only clauses 8.8 and 10.9 of NIS/IEC 61400-1:2019 shall be used.

13.13.2.5 Concrete Towers and Foundations

a. Standard for Concrete Design

The reference standard shall comply with the provisions of NIS/IEC 61400-1 and NIS/IEC 61400-2.

b. Partial Safety Factors

The partial safety factors given in clause 5.4 NIS/IEC 61400-1:2019 shall be applied for design of concrete structures as the minimum requirements.

13.13.2.6 Durability

a. Durability Requirements

To achieve the required design lifetime of the structure, adequate measures shall be taken to protect each structural element against the relevant environmental actions and the requirements defined in the NIS/IEC 61400 concerning durability shall apply.

The requirements for durability shall be included when considering the following:

i. structural conception.
ii. material selection.
iii. construction details.
iv. execution.
v. quality control.
vi. inspection.
vii. verification.
viii. special measures (e.g., use of stainless steel, coatings, and cathodic protection).

13.13.2.7 Wind Conditions

Wind turbine power plants shall be designed to safely withstand the wind conditions defined by the selected wind turbine class and the design values of the wind conditions shall be clearly specified in the design documentation and under extreme wind conditions which include wind shearing events, as well as peak wind speeds due to storms and rapid changes in wind speed and direction. Extreme Wind Speed Model (EWM) shall comply with NIS/IEC 61400-1 and Nigerian Meteorological standards.

13.13.2.8 Other Environmental Conditions

Additional environmental conditions shall be considered as specified in NIS/IEC 61400-3.

13.13.2.9 Temperature

The standard wind turbine classes under extreme temperature conditions shall range between -20 °C to +50 °C as provided in NIS/IEC 61400.

13.13. 3 Design Situation and Load cases

For design purposes, the life of a wind turbine can be represented by a set of design situations covering the most significant conditions that the wind turbine may experience. The load cases shall be determined from the combination of operational modes or other design situations, such as specific assembly, erection or maintenance conditions, with the external conditions. All relevant load cases with a reasonable probability of occurrence shall be considered, together with the behavior of the control system. The design load cases used to verify the structural integrity of a wind turbine shall be calculated by combining the following:

a. normal design situations and appropriate normal or extreme external conditions;

b. fault design situations and appropriate external conditions;
c. transportation, installation, and maintenance design situations and appropriate external conditions.

It shall be as contained in clause 7.4 of NIS/IEC 61400-1:2019.

13.13.4 Wind Turbine Power Plant Protection

Unless otherwise specified in this document, the protection design of a wind turbine electrical system shall comply with the requirements of NIS/IEC 60204-1, NIS/IEC 60364 (all parts), and NIS/IEC 61400-24.

13.13.5 Commissioning Tests

a. The manufacturer's instructions shall include the procedures for wind turbine testing after installation, to confirm proper, safe, and functional operation of all devices, controls, and apparatus in accordance with NIS/IEC 61400-1
.

b. The commissioning, operation, inspection, and maintenance procedures shall be specified in the wind turbine manual with due consideration of the safety of personnel.

13.13.6 Training

a. The licensee shall maintain a training program that includes training identified to be critical to success, including familiarity with relevant sections of the technical documents described in NIS/IEC 61400-1.
b. Additionally, Maintenance & Operations personnel shall be thoroughly trained by the installing Wind turbine Contractor and/or manufacturer on the following:
   i. System components
   ii. Maintenance
   iii. Troubleshooting
   iv. Monitoring

Training shall be video-taped and coordinated with wind turbine plant licensee owner’s engineer.

13.13.7 Power Evacuation

Wind turbine power plant shall be connected to the power grid when the frequency and the voltage at the point of common connection (PCC) conforms with the specifications in section 10.1 of Grid code or otherwise stated in the Connection Agreement (CA) between the transmission service provider and the wind power plant owner.

13.13.7.1 Conditions for Interconnectivity

Normal electrical power network conditions shall apply when the following parameters fall within the ranges stated in the Grid and Distribution Codes.

i. Voltage

ii. Frequency
iii. Voltage imbalance – the ratio of the negative-sequence component of voltage not exceeding 2 % (according to NIS/IEC 60038)
iv. Auto-reclosing cycles – auto-reclosing cycle periods of 0.1s to 5s for the first reclosure and 10s to 90s for a second reclosure shall be considered.

13.13.7.2 Grid-Interactive Inverter

Grid-interactive inverters, also known as grid-tied inverters, are devices used in renewable energy systems, to convert direct current (DC) electricity generated into alternating current (AC) electricity fed into the electrical grid. These inverters must be designed to synchronize with the utility grid, ensuring that the electricity they produce is compatible with the grid's voltage and frequency.

All compliance tests on grid-interactive inverters, and specific requirements on inverter ratings, inverter setpoints, and isolation transformers shall be carried out as contained in section 13.3.1.1, 13.3.1.2, 13.3.1.3 and 13.3.1.4 of this standard.

13.13.7.3 Transmission Conductors and other Components

Additional requirements on transmission conductors, power transformer and other components specific to wind turbine interconnectivity shall be as contained in clauses 10.16, 10.19, 10.20 and 10.21 of NIS IEC 61400, NIS IEC 61439-1 and NIS IEC 61439-6.

13.13.7.4 Stand-Alone Inverters

Stand-alone inverters, also known as off-grid inverters, are devices used in independent power systems where there is no connection to the utility grid. These inverters convert direct current (DC) electricity, typically generated by renewable energy sources into alternating current (AC) electricity.

13.13.7.5 Load Transfer Test

All compliance tests on stand-alone inverters shall be carried out as contained in sub clause 4.4.4.16 of NIS IEC 62109-2:2011.

13.13.8 Dedicated Loads

Where the approach of 4.7.5.5 is used, the installation instructions for the inverter shall include a warning that the inverter is only to be used with the dedicated load for which it was evaluated and shall specify the dedicated load.

13.13.9 Data Communication

All measurements and data relevant to recording and analysis must be logged with time stamps and an accuracy that ensures that such measurements and data can be correlated with each other and with similar recordings on the transmission grid.

Information for a wind power plant must be referred to, modelled, and grouped as specified in the NIS/IEC 61400-25 standard series

13. 14 Small Hydro Power Plant (SHPP)s

13.14.1 General

This standard is aimed at presenting technical specifications to be used in the development of small hydropower plant (SHPP). Relevant standards on civil, hydromechanical, electrical aspects from International Organization for Standardization (ISO), International Electromechanical Commission (IEC) and Institute of Electrical and Electronics Engineers (IEEE) have been included in this standard.

This regulation shall apply to both distributed generation and grid-connected Small Hydro power plants directly to the 330kV, 132kV, 33kV and 11kV networks. The minimum generation capacity of 20MW and 50MW shall apply for sources connected to 132kV and 330kV respectively, while that of 11kV and 33kV networks shall be 5MW and 20MW respectively.

13.14.2 Civil Work Design

13.14.2.1 Scope

This part of the standard specifies the flood control measures for the hydraulic structures of a small hydropower plant (SHPP), general engineering layout, as well as the type selection and the design of the water retaining structure, water releasing structure, diversion structure, powerhouse and switchyard, technical requirements for engineering safety monitoring, concrete and steel performance.

The applicable maximum height of a reservoir dam within the scope of this document is 30m for earth-rock fill dam, 50m for a concrete faced rock fill dam and 70m for a concrete gravity dam.

The main civil works of a SHPP covered within the scope of this standard includes:

i. Diversion structure
ii. Intake works
iii. Water conductor system
iv. Desilting tank
v. Forebay / surge tank
vi. Penstock
vii. Powerhouse building
viii. Tailrace channel

13.14.2.2 Design Data

The hydrometeorological data, river basin physiographic characteristics data, hydrological computation results of the basin and nearby areas, information on the impact of human activities and the other relevant data required for the design of the SHPP shall be determined as provided by ISO/IWA 33-2 and ISO/IWA 33-3.

The data upon which hydrological computation is based shall be checked for reliability, consistency and representativeness.

13.14.2.3 Water diversion structure

The types of the water diversion structure shall be determined after technical and economic consideration according to the development mode, operational requirements, topographical and geological conditions and types of water retaining structures, combined with the general layout and construction conditions of the project.

The following factors shall be taken into consideration for the selection of water diversion structures:

i. Size of SHPP
ii. Type of foundation strata
iii. Longitudinal slope of the river
iv. Availability of head

The design criteria for water diversion structures in SHPP projects shall be determined as described by ISO/IWA 33-3.

13.14.2.4 Weir Design

Selection of appropriate weir types (e.g., partial, gabion, trench, raised) shall be based on site conditions, hydrological data and the provisions provided by ISO/IWA 33-2 and ISO/IWA 33-3.

13.14.2.5 Selection of dam type

The type of dam shall be selected according to the topography, geology, hydrology and construction materials, as well as the preliminary planning results of the selected sites. The selection of dam type shall take into account the criteria described in ISO/IWA 33-2.

13.14.2.6 Design of dam

The structural design of dam shall take into account the provisions of ISO 23469 and ISO/TR 12930.

13.14.2.7 Design of Spillway

The spillway shall be designed to pass design flood at a pre-determined maximum allowable upstream water level. Spillway best suited to the prevailing site conditions shall be designed in accordance with the provisions of ISO/IWA 33-3.. The selection and design of energy dissipation devices best suited for a particular location shall be done in accordance with the provision of ISO/IWA 33-3.

13.14.2.8 Roller Compacted Concrete Dam

Roller compacted concrete dam (RCC Dam) is structurally like a concrete gravity dam and can be designed on similar lines. RCC dam shall be constructed using high-fly ash cement in the heating zone of the dam. Like the earth dam, dumpers and vibratory rollers shall be used for compacting the concrete.

13.14.2.9 Design and Construction Considerations

Design and layout of appurtenant structures, construction planning and treatment of joints shall take into consideration the advantages and disadvantages of the rapid construction that is possible with RCC.

13.14.2.10 Earth Dam

Earth Dams shall be designed and constructed using any type of locally available material.

13.14.2.10.1 Criteria for safe design of earth dams

The following safety criteria shall be considered in the design of an earth dam:

i. There shall be no possibility of the dam getting overtopped by flood waters.
ii. The seepage line should be well within the downstream face.
iii. The upstream and downstream slopes should be stable under worst conditions.
iv. The foundation shear stresses should be within safe limits.
v. The flow of water from upstream to downstream face should be controled.
vi. The upstream face should be protected against wave action and the downstream face against rain cuts.

13.14.2.10.2 Safety against overtopping

The following precautions shall be taken against overtopping:

i. Providing ample spillway capacity – As the overtopping of an earthen dam would result in failure creating catastrophic condition in the downstream side, the spillway flood hydrograph shall not be underestimated and spillway capacity should be on the conservative side.

ii. Provision of sufficient freeboard – The freeboard shall be sufficient to prevent overtopping by waves and should take into account the settlement of embankment and foundation. Freeboard for wave run up on slope shall be provided in accordance with the provisions of ISO/IWA 33-3.

13.14.2.10.3 Control of seepage line

The seepage line in the dam section shall not cut the downstream face of the dam and thereby produce softening or sloughing of the toe.

13.14.2.10.4 Control of seepage

The seepage through an earth dam shall be controlled by providing an effective cut-off.

13.14.2.10.5 Upstream and downstream slopes of the dam

Berms shall be provided on the downstream as well as upstream slopes to ensure the stability of the Dam.

The stability of the dam shall be determined and analysed under performance of loading conditions.

13.14.2.10.6 Safety against piping

Safety against piping shall be obtained by surrounding the drainage toe or horizontal or vertical drainage on all sides by graded filter.

13.14.2.10.7 Upstream and downstream slope protection

Provision shall be made for protection of the upstream and downstream slopes of the embankment dam.

13.14.2.11 INTAKE WORKS

The intake shall be designed to draw the required amount of water at minimum reservoir level,

minimum amount of sediment, check entry of trash and debris and minimal head loss. The following design details shall be considered:

i. The centre line of the intake and the size of inlet should be such that the intake could draw the required amount of water at minimum reservoir level without vortex formation and at a sufficiently low velocity.
ii. The sill of the intake should be kept at the highest possible level to reduce silt entry up to minimum extent.

iii. Looking from the river towards the bank, the intake, as far as possible should be located on the concave side to reduce silt content.

iv. The inlet opening should be of bell mouth shape and transitions should be hydraulically streamlined.

v. A trash rack structure shall be provided at the entrance of the intake gate.

13.14.2.11.1 Types of Intakes

The intakes can be broadly classified as Run-of-river type intakes, and Reservoir type intakes. The design of intake structures to efficiently and safely divert water from the river or stream to the water conveyance system shall be as contained in ISO/IWA 33-2.

13.14.2.11.2 Run-of-river Type Intakes

13.14.2.11.2.1 Intake just upstream of a raised weir / barrage

In this case an under-sluice with a low crest shall be provided adjacent to the bank, where the intake is proposed. A divide wall up to the end of intake shall be provided by extending the pier of the river side end of the under-sluice, thus creating a deep pool. The intake is aligned at 90o to 110o to the weir / barrage axis with its sill as much above the crest of the under-sluice bays as possible.

13.14.2.11.2.2 Intakes for canal power house or barrage power houses

An intake which is an integral part of the power house is located across large canals to utilize

the head of a canal fall or across a river to utilize the head created by the barrage. In such power houses Kaplan turbines with concrete spiral casing / bulb turbines shall be used for power generation.

13.14.2.11.2.3 Forebay Intake

In canal power projects, where the power house is planned at some distance from the intake location and head, Forebay Intake shall be appreciable. The free flow of the canal shall be terminated in a basin known as forebay and the intake for the penstocks provided at the downstream end of the forebay. The forebay is a broadened portion of the canal which is utilized to absorb the surges created by the load variations of the power house.

13.14.2.11.2.4 Reservoir Type Intakes

13.14.2.11.2.4.1 Intake in Concrete or Gravity Dam

When the powerhouse is located at the toe of a concrete or gravity dam and the penstock is embedded in the dam body, a semi-circular cage type intake shall be provided at upstream face of the dam.

13.14.2.11.2.4.2 Intake for earthen dam

In case of an earthen dam, the water conduit shall not be taken through the dam. In this case the pressure conduit takes off from a suitable place in the reservoir.

13.14.2.12 Hydraulic design

13.14.2.12.1 Obligatory levels of tunnel

In case of a pressure tunnel the depth of intake shall be such that no air is sucked in under any condition. The location of outlet of a tunnel shall be such that the entry of air would not adversely affect tunnel operation and safety provided that sufficient precautions for preventing air locks are taken. The tunnels shall have positive gradient in the direction of flow, since they may have to be emptied and drained from time to time for the purpose of inspection and maintenance.

13.14.2.12.2 Cavitation

Design shall be such that negative pressures are avoided. To make sure that cavitation is avoided and to allow for uncertainties, the residual positive pressure shall not be less than 3m of water head in concrete lined tunnels.

13.14.2.12.3 Structural design

This standard specifies the requirements for the dams (diversion dams, weir dams), desilting basins and spill ways. The standards address stability, water flow capacity and sediment control.

13.14.3 Technical specifications for Hydro Mechanical Works

The overall layout of hydro mechanical structure shall be mainly to determine the location of gates and hoists, orifice size, gate type, number and operation mode and other layout requirements related to the operation of SHPP.

The technical specifications for hydro mechanical work, including the type of the gate be determined in the light of the operation requirements of the gate, the working conditions of the gate and the type of the hoist.

The technical specifications for hydro mechanical works shall be in accordance with the provisions of ISO/IWA 33-3.

13.14.3.1 Electromechanical

13.14.3.1.1 Selection of Turbine and Governing System

Selection of turbine and governing system for the SHPP shall be in accordance with the procedures contained in IEC 61362 standards.

13.14.3.1.2 Selection of Generator

To select a generator for SHPP, the guidelines provided in IEC 62006, IEC 61362 and IEC 61850 standards shall be followed in addition to the following:

i. Generator Rating: The generator shall be rated for the turbine's output at the rated head, with consideration for potential future changes in project conditions.
ii. Power Factor and Efficiency: The generator's power factor and efficiency shall meet the requirement of the interconnected transmission system.
iii. Turbine Type: The type of turbine (Kaplan, Pelton, etc.) influences generator design and should be considered in the selection process. (Table Required)
iv. Cooling and Insulation: The generator's cooling system and insulation should be appropriate for the operating environment, including altitude and temperature.
v. Excitation System: The excitation system is crucial for maintaining voltage and reactive power. It shall be selected based on the generator type and grid requirements.

13.14.3.1.3 Selection of Switchyard for SHPP

For selecting a switchyard for a small hydro power plant, IEC 61850 standards shall be applicable for ensuring proper integration with the grid, interoperability, and cybersecurity. Specifically, Substation computers and Ethernet switches should meet IEC 61850-3 and IEEE 1613 standard specifications.

13.14.4 Monitoring, control, protection and automation

The provisions of IEC 62443, and IEC 61850 on monitoring, control, protection and automation of SHPP shall apply for the selection of monitoring, control, protection and automation systems.

13.14.5 Power Evacuation and Inter connection with Grid

Small Hydro power plant shall be connected to the power grid when the frequency and the voltage at the point of common connection (PCC) conforms with the specifications in section 10.1 of the Grid Code.

13.14.5.1 Conditions for Interconnectivity

Normal electrical power network conditions shall apply when the following parameters fall within the ranges stated in the Grid and Distribution Codes.

i. Voltage
ii. Frequency
iii. Voltage imbalance – the ratio of the negative-sequence component of voltage not exceeding 2 % (according to NIS/IEC 60038)
iv. Auto-reclosing cycles – auto-reclosing cycle periods of 0.1s to 5s for the first reclosure and 10s to 90s for a second reclosure shall be considered.

13.14.5.2 Operation and maintenance of SHPP

Operations and maintenance of SHPP shall be as contained in IEEE 492, IEC 61850 and IEC 61362 standards

13.14.5.3 Erection Testing and Commissioning

Testing and Commissioning of SHPP shall be as contained in IEC 61362 standards.

13. 15 Biomass Power Plant

13.15.1 General

This standard is aimed at presenting technical specifications to be used in the development of Biomass power plant (BPP), the technical requirements for the development of different Biomass plant types (Direct Combustion, Gasification, Co-firing, Combined Heat and Power) and the lifecycle phases (Design, Construction, Operation, Commissioning and Decommissioning).

This standard shall apply to grid-connected BPP interconnected directly to the 330kV, 132kV, 33kV and 11kV networks. The minimum generation capacity of 20MW, and 50MW shall apply for sources connected to 132kV and 330kV respectively, while that of 33kV and 11kV networks shall be below 20MW.

13.15.2 Site Selection & Plant Design

The selection of site and plant design shall be in accordance with the provisions of IEEE 2800 standards.

13.15.2.1 Site Requirements

The following shall be considered in the selection of site for BPP:

a. Fuel logistics: Proximity to biomass sources (<50 km radius).
b. Environmental impact: Environmental Impact Assessment shall be carried out and ecologically sensitive areas avoided.
c. Grid connectivity: Compliance with the Grid Code for interconnection.

13.15.2.2 Plant Layout

The plant layout shall be designed to indicate the following:

a. Process flow: Fuel handling, combustion/gasification, power generation and emissions control.
b. Safety zones: Firebreaks and hazardous material storage.

13.15.2.3 Fuel Specifications and Handling

The fuel specifications and handling shall be in accordance with the provisions of ISO 17225 and ISO 20675 standards.

13.15.2.3.1 Feedstock Standards

a. Properties: Moisture (<30%), ash (<10%), chlorine (<0.2%).
b. Storage: The storage covered area shall be as stipulated in ISO 20049 to prevent degradation. In addition, the following shall be considered:
   i. Fuel Storage: Minimum 15-30 days fuel storage capacity
   ii. Moisture Content: Maximum 15% for efficient combustion
   iii. Particle Size: 2-50mm depending on combustion technology
   iv. Heating Value: Minimum 15 MJ/kg (dry basis)

13.15.2.3.2 Fuel Preparation

The biomass fuel preparation shall be in accordance with the requirements of ISO 20675. In addition, the following shall apply:

a. Size reduction: Chipping/grinding to ≤5 cm for fluidized beds.
b. Drying: Pre-treatment to ≤15% moisture for efficiency.

13.15.3 Biomass Power Generation Systems

13.15.3.1 Plant Configuration Requirements

a. Efficiency Standards: Minimum 25% electrical efficiency for small-scale plants (<10MW), 30% for larger plants
b. Availability: Minimum 85% annual availability factor
c. Plant Life: Design life of 25 years minimum

13.15.3.2 Combustion Technologies

13.15.3.2.1 Boiler design

a. Grate-fired: For high-ash fuels (e.g., rice husk).
b. Fluidized bed: For heterogeneous feedstocks (ISO 8130-5).
c. Boiler Efficiency: Minimum 80% (Higher Heating Value basis)
d. Steam Parameters: Pressure of 40-80 bar for small plants, up to 120 bar for larger plants and temperature of 400-500°C.
e. Emission Standards: As specified by NESREA emission limits.

13.15.3.2.2 Gasification Systems

a. Syngas cleanup: Tar removal (<50 mg/Nm³), particulate filtration.

b. Engine/turbine specifications: Adaptability to low-calorific value gas (≥4 MJ/Nm³).

13.15.3.2.3 Co-firing

The Blending ratios shall be ≤20% biomass with coal to avoid slagging.

13.15.4 Emissions Control

13.15.4.1 Pollutant Limits

The pollutant limits shall be in accordance with NESREA regulations - National Environmental (Air Quality Control) Regulations, S. I. No 88, 2021 (Amended).

13.15.5 Waste Management

Biomass waste shall be managed in accordance with NESREA regulations - National Environmental (Sanitation and Wastes Control) Regulations, S. I. No. 28, 2009.

13.15.6 Monitoring, Control, Protection and Automation Systems

SCADA requirements: Real-time tracking of the following:

a. Fuel feed rates.
b. Emissions (Continuous Emission Monitoring System (CEMS)).
c. Power output fluctuations.

13.15.7 Grid Interconnectivity

Normal electrical power network conditions shall apply when the following parameters fall within the ranges stated in the Grid and Distribution Codes.

i. Voltage
ii. Frequency
iii. Voltage imbalance – the ratio of the negative-sequence component of voltage not exceeding 2 % (according to NIS/IEC 60038)
iv. Islanding protection: islanding relays for grid failures.
v. Auto-reclosing cycles – auto-reclosing cycle periods of 0.1s to 5s for the first reclosure and 10s to 90s for a second reclosure shall be considered

13.15.8 Decommissioning

Ash disposal: This shall be in accordance with NESREA regulations - National Environmental (Sanitation and Wastes Control) Regulations, S. I. No. 28, 2009.

Equipment recycling: Metal recovery from boilers/turbines.

THE common seal of NIGERIAN ELECTRICITY REGULATORY COMMISSION was affixed pursuant to the ORDER of the COMMISSION

On this …….......................... day of……......................................………..... 2025.

CHAIRMAN/CEO