Power Transmission Projects

MANUAL
OF
SPECIFICATIONS and STANDARDS

Rajasthan Rajya Vidyut Prasaran Nigam Limited

INDEX

Abbreviations

The following abbreviations are used in this Manual of Specifications and Standards:

Abbreviation	Full Name
AC	Alternating Current
ACSR	Aluminium Conductor Steel Reinforced
ADSS	All Dielectric Self-Supporting
AIS	Association of Information System
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
BS	British Standards
CA	The Concession Agreement entered into between the Concessionaire and the Authority
CBI& P	Central Board of Irrigation and Power
CCEA	Cabinet Committee of Economic Affairs
CEA	Central Electricity Authority
CEB/FIB	Model Code for Concrete Structures “CEB Bulletin”
CENELEC	European Committee for Electro technical Standardization
CTU	Central Transmission Utility
DC	Double Circuit
DWSM	Dual-Window Single Mode
E&M	Electrical and Mechanical
EIA	Energy Information Administration
EHT	Extra High Tension
EN	Euro Norm (European) Standard
EPC	Engineering Procurement and Construction
GOI	Government of India
GOR	Government of Rajasthan
GPS	Global Positioning System
GSS	Galvanized Steel Stranded
Hz	Hertz

HV	High Voltage (as per Indian Electricity Rules)
ICAO	International Civil Aviation Organization
IE	Independent Engineer
IEC	International Electro technical Commission
IEEE	Institution of Electrical and Electronic Engineers
IEGC	Indian Electricity Grid Code
IS	Indian Standard
ISA	Independent Safety Assessor
ISO	International Standards Organization
ITU-T	International Telecommunication Union-Telecommunication Standardization Sector
JIS	Japanese Industrial Standards
KN	Kilo Newton
KV	Kilo Volt
KW	Kilo watt
LAN	Local Area Network
LED	Light Emitting Diode
LV	Low Voltage (as per Indian Electricity Rules)
MCB	Miniature Circuit Board
MDB	Main Distribution Board
NBC	National Building Code (of India)
NFPA	National Fire Protection Association
NMS	Network Management System
NEMA	National Electric Manufacture Associate
O&M	Operation and Maintenance
OPGW	Optical. Ground Wire
PPP	Public Private Partnership
PTFE	Poly Tetra Fluoro Ethylene
PVC	Polyvinyl chloride
P&T	Power and Telecom
RCC	Reinforced Cement Concrete
RI	Ride Index

RMS	Root mean square
ROW	Right of Way
RVPN	Rajasthan Vidyut Prasaran Nigam
SCADA	Supervisory Control and Data Acquisition
STU	State Transmission Utility
UV	Ultra Violet
UPS	Uninterrupted Power Supply
VGF	Viability Gap Funding
VVVF	Variable Voltage Variable Frequency
WAN	Wide Area Network
XLPE	Cross Linked Poly Ethylene

Definitions

In this Manual of Specifications and Standards (the "**Manual**"), the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

Term	**Definition**
Authority	shall have the meaning attributed thereto in the array of Parties as set forth in the Recitals in the Transmission Agreement;
Concessionaire	shall have the meaning attributed thereto in the array of Parties as set forth in the Recitals in the Transmission Agreement;
DISCOM	shall mean a distribution company which is licensed to distribute electric power;
Earthing or Grounding	shall mean the connection of equipment enclosures and noncurrent carrying metal parts to earth to provide safety to personnel, public and to the equipment;
Government	means the Central Government or the Government of the State; as the context may require;
Maintenance	shall include visual inspection, adjustment, replacement or repair carried out on equipment, sub-systems or systems which results in the item undergoing attention being preserved within maintenance tolerances or returned to its design tolerances;
Manual	shall mean this Manual of Specifications and Standards;
O&M	means the operation and maintenance of the Transmission System and includes all matters connected with or incidental to such operation and maintenance, and provision of transmission services and facilities in accordance with the provisions of this Agreement;
Specifications and Standards	shall mean the specifications and standards relating to the quality, quantity, capacity and requirements for the Transmission System, as set forth in this Manual, and any modifications thereof, or additions thereto, as included in the design and engineering for the Transmission System if the Concessionaire can demonstrate to the IE, prior to use by him, that such modification or alterations are superior or more pertinent to the Project than the specifications and standards specified in this Manual;

Term	Definition
Substation	means a station for transforming or converting electricity for the transmission thereof and includes transformers, converters, switchgears, capacitors, synchronous condensers, structures, cable and other appurtenant equipment and any buildings used for that purpose and the site thereof;
Tests	shall mean all the tests necessary to determine the completion of Transmission System in accordance with the provisions of the Concession Agreement;
Works	shall refer to all labor, materials and equipment to be fitted into the stations and structures that are necessary to implement the Operation and Maintenance requirements;
Others	Any capitalized term used herein and not specifically defined shall have the meaning ascribed to such term in the Model Transmission Agreement notified by the Ministry of Power under Section 63 of the Electricity Act, 2003 and published by the Planning Commission

SECTION 1

GENERAL

1.1 This Manual is applicable for Planning, Design, Construction, Operation and Maintenance of a) 400kV D/C (Twin ACSR Moose) Transmission Lines b) associated 400kV/220kV substation, through Public Private Partnerships ("the Project"). The scope of the work shall be as defined in the Concession Agreement. This Manual shall be read harmoniously with the intent of the Concession Agreement.

1.2 The System Capacity shall be constructed, completed, operated and maintained in conformity with the Specifications and Standards set forth herein.

1.3 Concessionaire shall propose Air insulated or Gas insulated substations as proposed in the General Layouts attached with the manual.

1.4 The requirements of Transmission lines and substation are covered in Part A, and Part B respectively, of this manual.

1.5 The Transmission System shall conform to the requirements of design and specifications set out in this Manual, which unless specified otherwise, are the minimum prescribed. The project report and other information provided by the Authority shall be used by the Concessionaire only for its own reference and for carrying out further investigations. The Concessionaire shall be solely responsible for undertaking all the surveys, investigations and detailed designs in accordance with Good Industry Practice and shall have no claim against the Authority for any loss, damage, risks, costs, liabilities or obligations arising out of or in relation to such surveys, investigations and designs.

1.6 All works, methods and workmanship shall be in accordance with this Manual of Specifications and Standards and Good Industry Practice.

1.7 All plant and equipment, including replacements thereof, shall be new, unused, and of the most recent or latest models unless provided otherwise in the Transmission Agreement.

1.8 Concessionaire shall carry out residual life assessment and appropriate condition based maintenance in accordance with recommendations of “CBI&P Manuals on Transmission Line Maintenance” and “CBI&P Manual on EHV Substations” and also

carry out general maintenance as per the Maintenance Manual and Good Industry Practice so as to non-intrusively determine equipment health, arrest undue deterioration in performance, improve availability, regain lost capacity and extend useful life beyond normal standard life span.

1.9 The Concessionaire shall take all requisite measures for appropriate operation and maintenance as per relevant codes, standards and the Maintenance Manual and adopt requisite life extending procedures or replacement measures to guard against undue capacity loss and de-rating of equipment as per Good Industry Practice.

1.10 At least 2 weeks prior to commencement of the work, the Concessionaire shall draw up a Quality Assurance Manual (QAM) covering the Quality System (QS), Quality Assurance Plan (QAP) and documentation for all aspects of the Project works and send three copies each to the Independent Engineer (IE) for review. The QAM shall conform to Applicable Laws, Good Industry Practice in vogue and the provisions of the Concession Agreement.

1.11 The Transmission System shall conform to the following Acts, Rules, Regulations and Codes for the Transmission System:

(a) Indian Electricity Act - 2003;
(b) Indian Electricity Grid Code (IEGC);
(c) Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2013;
(d) CEA (Technical Standards for construction, operation and maintenance of Electrical Plants and Electric Lines) Regulation, 2010;
(e) CEA (Safety requirements for construction, operation and maintenance of transmission lines) Regulation, 2011;
(f) CEA (Grid Standards for operation and maintenance of transmission lines) Regulation, 2006;
(g) CEA (Safety and electricity supply) Regulation, 2008 and other applicable Laws;
(h) Central Board of Irrigation and Power (CBI&P): Manual on Commissioning Procedures for Transmission Line;
(i) Central Board of Irrigation and Power (CBI&P): Manual on Maintenance of Transmission Line;
(j) Central Board of Irrigation and Power (CBI&P): Transmission Line Manual;
(k) Central Board of Irrigation and Power (CBI&P): EHV substation Manual; and
(l) Central Electricity Authority (Installation and Operation of Meters) Regulations, 2010.

In the event of conflict between standards and specifications prescribed in two or more of the aforesaid codes, the Concessionaire shall be at liberty to rely on one of the aforesaid codes and on Good Industry Practice. Provided, however, that in the event of any such conflict, the following codes shall have overriding priority in the order listed below:

(i) Specifications and Standards set out in this Manual; and

(ii) CEA (Technical Standards for construction, operation and maintenance of Electrical Plants and Electric Lines) Regulations, 2010.In the event of any conflict between the requirement of the International Standards or codes and the requirement of the BIS Standards or Codes, the latter shall prevail.

1.12 The latest version of the aforesaid codes, standards and specifications, which have been published before the last date of bid submission shall be considered applicable.

1.13 The terms '**Inspector**' and '**Engineer**' used in the aforesaid codes, standards or specifications shall be deemed to be substituted by the term "**Independent Engineer**", to the extent it is consistent with the provisions of the Concession Agreement and this Manual. The role of the Independent Engineer (IE) shall be as defined in the Concession Agreement.

1.14 Where no standards exist, as in the case of patented or special materials, all such equipments and materials shall be of reputed make. Full details of the material and any quality control tests to which they may be subjected shall be submitted to the Independent Engineer for review and comments, if any.

1.15 In the absence of any specific provision on any particular issue in the aforesaid codes, standards or specifications read in conjunction with the Specifications and Standards contained in this Manual, the Concessionaire shall be at liberty to rely on any international standard in consultation with the IE.

1.16 The design of a transmission system shall be fully integrated and compatible with all other transmission systems that constitute the transmission network of the State so that the overall requirements of the Transmission System may met.

1.17 The requirements stated in the Manual are the minimum. The Concessionaire will, however, be free to adopt international practices, alternative specifications, materials and standards to bring in innovation in the design and construction; provided they are better or comparable with the standards prescribed in the Manual. The specifications and techniques which are not included in the aforesaid codes, standards or specifications shall be supported with authentic standards and specifications reflected in other internationally recognized codes, standards and

specifications. Such a proposal shall be submitted by the Concessionaire to the Independent Engineer. In case, the Independent Engineer is of the opinion that the proposal submitted by the Concessionaire is not in conformity with any of the international codes, standards and specifications, then he will record his reasons and convey the same to the Concessionaire for compliance. A record shall be kept by the Independent Engineer, of the non-compliance by the Concessionaire of the minimum Specifications and Standards specified in the Manual. Adverse consequences, if any arising from any such non- compliance, shall be dealt with in accordance with the provisions of the Concession Agreement.

1.18 Climatic Conditions and Meteorological data : Equipment to be supplied and other services to be executed shall be suitable for satisfactory continuous operation under the following tropical conditions:

Sr.No.	Description	Parameters
1	Maximum operating temperature	
	Conductor (deg. C)	75
	Ground Wire(deg. C)	53
2	Ambient temperature	
(a)	Max. Ambient temp. (deg.C)	50
(b)	Mean annual temp. (deg.C)	32
3	Min ambient temp. (deg.C)	(-) 2.5
4	Relative humidity	
(a)	Maximum (percent)	90
(b)	Minimum (percent)	10
5	Wind Zone (velocity)	4 (47 m/s)
6	Average rainfall per annum	100-1000mm
7	Rainy months	May to August
8	Rainy days in a year	70
9	Average no. of thunder storm days per annum	25
10	Height above mean sea level (m)	530 m
11	Basic Seismic co-efficient	
(a)	Horizontal acceleration (g)	0.08
(b)	Vertical acceleration (g)	0.04
12	Terrain	Mixed containing mountains, forest, rivers, rocky, desert

1.19 General considerations for planning, design and construction:

1.19.1 The Concessionaire shall perform the detailed survey along the route alignment, prepare route profiles, tower spotting, optimization of tower locations, measurement of soil resistivity and geotechnical investigation at specified locations, assessment of quantities of different types of towers, body extensions, tower schedule, tower capacity chart, sag template, sag tension chart, etc.

1.19.2 The Concessionaire shall also be responsible for undertaking check survey required for starting the work of foundations. The detailed survey and check survey shall be performed by qualified and experienced personnel and supervised by the qualified surveyor.

1.19.3 Right-of-way : Clearing of obstructions falling in the right-of-way as per IS 5613 (Part 3, Section 2) and lopping or trimming of the portion of the trees obstructing the line of sight during detailed survey and falling within the minimum electrical clearance zone shall be the responsibility of the Concessionaire.

1.19.4 The Concessionaire shall perform detailed soil investigation at all angle tower locations and tower locations for railway crossings, major road crossings, power line crossings and wherever soil strata differ from normal locations. Detailed geotechnical investigation are required to be performed at specified number of tower locations to provide sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters to verify the bearing capacity, and uplift resistance and settlement constraints at site on the basis of which the foundation of transmission line towers can be classified and designed rationally.

1.19.5 All crossings of power lines - road crossings, railway crossings, river crossings, power line to power line and power line to tele-communication lines etc. - shall be undertaken in compliance with the requirements of the Indian Electricity Rules, 1956, applicable codes, the requirements of concerned authorities owning the en-route utility in respect of safety of its users, and security of the Transmission System, in accordance with Good Industry Practice. All Statutory Clearances like PTCC, Forest, railway crossing, wild life, aviation etc to be arranged by concessionaire.

1.19.6 The Concessionaire shall perform detailed topography survey to define the contours of the substation/s sites. The report shall be detailed and shall form basis of the finalization of the substation level. Approach road for the substation site and connection points for the utilities such as plumbing and drainage system in the

vicinity shall be clearly brought out.

1.19.7 The Concessionaire shall perform detailed soil investigation at the substation site. Detailed geotechnical investigation are required to be performed at specified number locations to provide sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters to verify the bearing capacity, and uplift resistance and settlement constraints at site on the basis of which the foundation of equipment, transformers, control building in case of AIS substation/ GIS building can be classified and designed rationally.

1.19.8 The Concessionaire shall measure soil resistivity at the substation locations as per latest codes and standards.

1.19.9 The Concessionaire shall comply with all the applicable statutory rules pertaining to Factory Act, Fire Safety Rule, Water Act for Pollution control, Explosives Act, etc. Provisions of Safety, Health and Welfare according to Factories Act shall also be complied with. Statutory clearances and norms of State Pollution Control Board shall be followed.

1.20 Safety measures:

1.20.1 The Concessionaire shall develop, implement and administer a surveillance and safety program for providing a safe environment on or about the Project, and shall comply with the safety requirements set forth in the Concession Agreement.

1.20.2 The Concessionaire shall also be responsible for ensuring compliance of all labour laws and regulations including those relating the welfare of workers engaged both directly and indirectly on the Project, besides their occupational safety and health.

1.20.3 The Concessionaire shall set up a field laboratory for testing of materials and finished products as stipulated in QAM. It shall make necessary arrangements for additional/ conformity testing of any materials/products at the government accredited laboratory, for which facilities at site laboratory are not available.

1.21 Environment mitigation measures: The Concessionaire shall carry out tests and monitor various parameters impacting the environment of the Project keeping in view the guidelines of the Ministry of Environment and Forests and submit proposals for mitigation of adverse environment impact for review and comments of the IE, and undertake implementation thereof.

1.22 Project Monitoring System: The Concessionaire shall procure information technology based system for effective project monitoring. The IT system shall

monitor status of engineering, design, testing, supplies and physical progress of site activities as well as O&M and help in identifying the bottlenecks in achieving the scheduled completion of works.

1.23 Review and comments by the Independent Engineer: In cases where the Concessionaire is required to send any drawings or documents to the Independent Engineer for review and comments, and in the event such comments are received by the Concessionaire, it shall duly consider such comments in accordance with the Concession Agreement and Good Industry Practice for taking appropriate action thereon.

1.24 Tests : Factory Inspection Tests (FAT) shall be performed on all the equipment at the manufacturer's works before dispatch as per relevant Indian/International standards and as per Good Industry Practice.

All the systems shall be tested as per relevant Indian/International standards and as per Good Industry Practice.

The Concessionaire shall make necessary arrangements for conformity testing of any materials/products at the government accredited laboratory/ field laboratory as stipulated in QAM.

1.25 Definitions and Interpretation:

1.25.1 All the obligations of the Concessionaire arising out of the provisions of this Manual shall be discharged in a manner that conforms to the provisions of the Transmission Agreement.

1.25.2 Unless specified otherwise in this Manual, the definitions contained in the Model Transmission Agreement (MTA) for Public Private Partnership (PPP) in Power Transmission System as published by the Planning Commission, Government of India shall apply.

Part- A

TRANSMISSION LINE

SECTION 2

TRANSMISSION TOWER

2.1 Design, Manufacturing, Fabrication, Galvanizing and Testing of towers shall conform to the provisions of IS: 5613 and IS: 802 (Part-1/2 and 3) as amended upto date.

2.2 The codes of Bureau of Indian Standards (BIS) mentioned below or equivalent International Standards as amended up to date shall be applicable to the material and process used in the manufacture of towers and tower accessories:

Indian Standards (IS)	Title	International and Internationally recognized
IS 2	Rules for rounding off numerical values	
IS 209	Zinc Ingot- Specification	
IS-269	Ordinary Portland Cement, 33 grade-Specification	
IS 278	Galvanized steel barbed wire for fencing-Specification	
IS 432 (Part 1)	Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement, Part 1: Mild steel and medium tensile steel bars	
IS 432 (Part 2)	Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement, Part 2: Hard-drawn steel wire	
IS 456	Plain and reinforced concrete- Code of practice	
IS 800	General Construction In Steel - Code of Practice	
IS 802 (Part 1/Sec1) and IS 802 (Part 1/Sec 2)	Code of practice for use of structural steel in overhead transmission line towers: Materials and loads permissible stresses **" Note:** IS-802 1995(part1/sec1, Clause No. 12.1.2 specifies "nil wind condition" for Suspension Towers under broken wire condition, which may be substituted by "75% wind condition" for the purpose of design and construction"	

IS 802 (Part 2)	Code of practice for use of structural steel in overhead transmission line: Fabrication, galvanizing, inspection and packing	
IS 802 (Part 3)	Code of practice for use of structural steel in overhead transmission line: Testing.	
IS 808	Dimensions for hot rolled steel beams, column channels and Angle sections	
IS 875	Code of Practice for Design Loads (Other than Earthquakes) for Buildings and Structures.	
IS 1200	Method of Measurement of Building and Civil Engineering Works.	
IS 1363 (Part 1)	Hexagon Head Bolts, Screws and Nuts of Product Grade C - Part 1 : Hexagon Head Bolts (Size Range M 5 to M 64)	
IS 1363 (Part 3)	Hexagon Head Bolts, Screws and Nuts of Product Grade C - Part 3 : Hexagon Nuts (Size Range M5 to M64)	
IS 1367 (Part 1)	Technical supply conditions for threaded steel fasteners, Part 1: General requirements for bolts, screws and studs	
IS 1367 (Part 3)	Technical supply conditions for threaded steel fasteners, Part 3: Mechanical properties of fasteners made of carbon steel and alloy steel	
IS 1367 (Part 6)	Technical supply conditions for threaded steel fasteners, Part 6: Mechanical properties and Test methods for nuts with specified proof loads	
IS 1367 (Part 13)	Technical supply conditions for threaded steel fasteners, Part 13: Hot Dip Galvanized Coatings on threaded Fasteners	
IS 1477	Code of Practice for Painting of Ferrous Metals in Buildings.	
IS 1489	Portland Pozzolana cement	
IS 1573	Specification for Electroplated coatings for zinc on iron and steel.	
IS 1786	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement	
IS 1852	Rolling and Cutting Tolerances of Hot Rolled Steel Products.	

IS 1893	Criteria for earthquake resistant design of structures	
IS 2016	Specification for Plain washers	ISO/R887
IS 2062	Hot rolled medium and high tensile structural steel	
IS 2074	Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome, Priming- Specification	
IS 2551	Danger notice plates	
IS 2629	Recommended practice for hot dip galvanizing of iron and steel	
IS 2633	Method of testing uniformity of coating *on* zinc Coated articles	
IS 3043	Code of Practice for Earthing.	
IS 3063	Fasteners- single coil rectangular section spring lock washers	DIN-127
IS 3757	High strength structural bolts	
IS 4091	Code of practice for design and construction of foundations for transmission line towers and poles	
IS 4759	Hot-dip zinc coatings on structural steel and other allied product	
IS 5613 (Part 2) Section 1 Section 2	Code of practice for design, installation and maintenance of overhead power lines: (Up to 220 kV) Design	
IS 5613 (Part 3) Section 1 Section 2	Code of practice for design, installation and maintenance of overhead power lines: (400kV lines)Design Installation and maintenance	
IS 5369	General Requirements for Plain Washers and Lock Washers	
IS 6610	Specification for Heavy washers for steel	
IS 6623	High Strength Structural Nuts.	
IS 6639	Specification for Hexagonal bolts for steel	
IS 6745	Specification for Methods for the determination of the mass of zinc coating on zinc coated iron and steel articles	
IS 7215	Specification for Tolerance for Fabrication of steel structures	

IS 10238	Fasteners- Threaded steel fastener- Step bolts for steel structures	
IS 12427	Fasteners- Threaded steel fasteners- Hexagon head transmission tower bolts	
	Indian Electricity Rules 1956	
Publication No.19(N)/700	Regulation for Power Line crossings for Railway tracks-1987	
CBI&P Publication No. 268, 290 and	Transmission line Manual	

2.3 Tower Steel Sections: Steel section to be used in fabrication of towers, extensions and stub setting templates shall be of tested quality conforming to IS 2062. No individual members shall be longer than 7000 mm. Use of high tensile steel as per IS 8500 is permitted for fabrication of towers.

2.4 Grounding of Towers: Grounding of towers shall be done in accordance with IS 5613 (Part 3/Section 2).

2.5 Sag Tension calculation for conductor and ground wire shall be made in accordance with the relevant provisions of IS 5613 (Part 3 / Sec 1).

2.6 Step Bolts and Ladders: Each tower shall be provided with step bolts on two diagonally opposite legs which shall conform to IS 5613 Part 3/Sec-2.

2.7 Number, Danger, circuit and Phase Plates: Each tower shall be provided with number plates, danger plates, circuit plates, phase plates and bird guards. Danger plates shall conform to IS 2551. The number and phase plates shall conform to IS 5613 (Part 3/Section-1). Six Nos. Saw tooth type bird guards should be provided for each suspension type tower, conforming to IS: 5613 (part-2, Sec-1).

2.8 Anti-Climbing Device: Towers shall be fitted with anti-climbing devices of spike type conforming to IS 5613 (Part 3/Section 1). The height of the anti-climbing device shall be provided approximately 2.5 to 3.5 meter above ground level.

2.9 Aviation Requirements: Aviation requirements shall be as per IS 5613(Part-3/ Section-1).

2.10.1 Day Marking:

(a) Painting of Towers: The portion of towers (excluding cross arms) above 45 meter height shall be painted. The painting of towers shall generally conform to relevant

provisions in IS 1477 (Part 1 and2). The paints to be used for painting shall be in accordance with IS 2074.

For Surface preparation, the etching of galvanized surface of erected tower members with suitable etching or wash primer is to be done as per IS:1477. One coat of wash primer and zinc chromate primer shall be applied. The primer to be used shall conform to IS: 2074.

For final painting, two coats of international deep orange or red and snow white paint at alternate intervals are to be applied.

(b) Line/Span Markers: Sphere type span marker of 600mm/ diameter shall be provided on the earth wire. The design of the markers and their fixing arrangement should be such that they can withstand the wind pressure and shall not induce excessive amount of vibration strain on earth wire. Appropriate clamping device of cast aluminium alloy are to be provided for clamping. The spheres are hollow and UV protected against fading of color and weathering as per IS.

2.10.2 Visual Aids: Visual aids (Night Markers) consisting of medium intensity and two/ four (as applicable) low intensity lights along with storage battery and solar panel, control panel, cables, clamps, other accessories etc. shall be provided on the transmission line towers as per the provision of IS –5613 (Part -II/ section –I) latest amendments regarding night and day visual aids for denoting transmission line structure as per the requirement of Directorate of Flight safety. Low and Medium intensity lights to be provided on each tower shall conform to the ICAO requirement /relevant BS and shall have weather protection of minimum IP-55 class. Storage battery, solar panels, control panels, cables and clamps shall conform to relevant Indian Standard or any other internationally recognized standard. These should be highly resistant to water, abrasion, nail, impact and other environmental factors.

Necessary sensor/timer shall be provided in the system to “switch on” the light automatically in the evening and poor visibility period and switch off the same during day time and normal visibility period.

2.11 Galvanization: Hot dip Galvanization of tower members shall conform to IS: 2629 and IS: 4759 and that of fasteners to IS: 1367 (Part-13) and IS: 5358. Spring washers shall be electro-galvanized as per grade4 of IS: 1573. All galvanized material shall withstand tests as per IS: 2633.

2.12 Fasteners-Bolts, Nuts and Washers: Half threaded hexagonal, chamfered, galvanised GI bolts and nuts conforming to IS: 6639 and IS: 12427 of property class 5.6 as

specified in IS: 1367 shall be used. The heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight. The redundant members of first 2 (two) panels from ground level shall be connected with anti-theft bolts and nuts along with spring washers whereas the balance joint shall be connected with hexagonal bolts and joints.

2.13 All fasteners used in transmission towers i.e nuts, step bolts, plain washers and spring washers shall conform to the following codes of the Bureau of Indian Standards (BIS) and British Standards.

IS 209	Zinc Ingot- Specification (Fourth Revision with amendment no. 2)
IS 10238	Fasteners- Threaded steel fastener- Step bolts for steel structures
IS 12427	Specification for transmission tower bolts (With latest amendments)
IS 14394	Industrial fasteners-hexagon nuts of product grade C- Hot dip galvanized- Specification (size range M12 to M36)
IS 1363 (Part 3)	Hexagon head bolts, screws and nuts of product grade C: Hexagon nuts (size range M5 to M64) (Third revision)
IS 1367 (Part 1)	Technical supply Conditions for Threaded steel Fasteners, Part 1: General information(fourth revision)
IS 1367 (Part 2)	Technical supply Conditions for Threaded steel Fasteners, Part 2: Tolerances for fasteners- bolts, screws, studs and nuts- Product grades A, B & C (third revision)
IS 1367 (Part 3)	Technical supply conditions for threaded steel fasteners, Part 3: Mechanical properties of fasteners made of carbon steel and alloy steel (fourth revision)
IS 1367 (Part 6)	Technical supply conditions for threaded steel fasteners, Part 6: Mechanical properties and Test methods for nuts with specified proof loads (third revision)
IS 1367 (Part 9/Sec 2)	Technical supply conditions for threaded steel fasteners, Part 9: Surface discontinuities, Section 2: Bolts, screws and studs for special applications (third revision with amendment no. 1)
ISO 6157-3	Fasteners -- Surface discontinuities -- Part 3: Bolts, screws and studs for special requirements
IS 1367 (Part 11)	Technical supply conditions for Threaded steel Fasteners, Part 11: Electroplated coatings (third revision)

IS 1367 (Part 13)	Technical supply conditions for threaded steel fasteners, Part 13: Hot Dip Galvanized Coatings on threaded Fasteners (second revision)
IS 1367 (Part 17)	Industrial fasteners - Threaded steel fasteners - Technical supply conditions Part 17 Inspection, sampling and acceptance procedure (fourth revision)
IS 1367 (Part 18)	Industrial Fasteners - Threaded Steel Fasteners - Technical Supply Conditions - Part 18 : Packaging (third revision)
IS 1368	Dimensions for end of parts with external ISO metric threads (third revision)
IS 1369 (Part 1)	Fasteners - Thread Run-Outs and Undercuts Part 1 Dimensions for Screw Thread Run-Outs for External ISO Metric Threads (third revision)
IS 1369 (Part 2)	Fasteners - Thread runout and undercuts Part 2 Dimensions for screw thread undercuts for external ISO metric threads (third revision)
IS 1369 (Part 3)	Fasteners - Thread Run-Outs and Undercuts - Part 3 : Dimensions for Screw Thread Run-Outs and Undercuts for Internal Threads (Blind Tapped Holes) (third revision)
IS 2016	Specification for plain washers (First revision with amendment no. 4)
IS 2633	Methods for testing uniformity of coating on zinc coated articles (Second revision)
IS 4218 (Part 1)	ISO general purpose metric screw threads, Part 1: Basic and design profile (Second revision)
ISO 68-1:1998 (Part 2)	ISO general purpose screw threads- Basic profile- Part1: Metric screw threads
ISO 261:1998 (Part 3) -	ISO general purpose metric screw threads- General plan
ISO 724:1993	ISO general purpose metric screw threads- Basic dimensions
ISO 262:1998	ISO general purpose metric screw threads - Selected sizes for screws, bolts and nuts
IS 4218 (Part 6)	ISO Metric Screw Threads - Part VI : Limits of Sizes for Commercial Bolts and Nuts (diameter range 1 to 52 mm)
IS 4759	Hot dip zinc coating on structural steel and other allied products (third revision with amendment no. 1)

IS 1570 (Part I)	Schedules for wrought steels, Part 1: Steels specified by tensile and/or yield properties (first Revision) with amendment No.1)
IS 1573	Electroplated coatings of zinc on iron and steel (second revision)
IS 2004	Carbon steel forgings for general engineering purposes (third revision)
IS 6745	Methods for determination of weight of zinc coating on zinc coated iron and steel articles (with amendment No.5)

2.14 Tower Foundation: The design requirements of plain cement concrete and reinforced cement concrete Tower foundations of self-supporting galvanized lattice towers for 400 kV Transmission Line shall conform to IS:456-Indian Standard Code of Practice for Plain and Reinforced Concrete.

The Indian Standard Specifications as mentioned below shall be applicable to the materials used in the preparation of concrete.

IS 269	Ordinary Portland Cement, 33 grade- Specification
IS 383	Coarse and Fine Aggregates From Natural Sources For Concrete
IS 5613(Part 3/ Section 2)	Code of Practice for Design, Installation and Maintenance of Overhead Power Lines - Part 3 : 400 kV Lines - Section 2 : Installation and Maintenance
IS 4091	Code of practice for design and construction of foundations for transmission line towers and poles

SECTION 3

INSULATORS

3.1 Insulators suitable for 400 kV over-head transmission lines shall be used. These shall be suitable for being installed directly in air suspended on the tower cross arms or anchored to the power cross arms of 400 kV D.C. line on suspension and tension towers. The ratings shall be 120 KN and 160 KN for discs in suspension and tension respectively. They shall be ball and socket type of porcelain or toughened glass. Alternatively, long rod insulators of the same ratings may also be used.

3.2 The insulators used shall conform to the following standards as applicable to the appropriate insulators.

IEC 60120	Dimensions of ball and socket couplings of string insulator units.
IS 137	Ready mixed paint, brushing, matt or eggshell flat, finishing, interior to Indian Standard Colour as required. (Amendment no 3)
IS 209	Zinc Ingot- Specification (Fourth Revision with amendment no. 2)
IEC 60305	Characteristics of string insulators
IS 1449	Methods of sampling of manganese ores
IS 1473	Methods of chemical analysis of Manganese ores
IEC 60318-6	Eacoustics - Simulators of human head and ear - Part 6: Mechanical coupler for the measurement on bone vibrators
IEC 60383	Insulators for overhead lines with a nominal voltage above 1 000 v-part 2: insulator strings and insulator sets for a.c. systems - definitions, test methods and acceptance criteria
IS 406	Method of Chemical Analysis of slab zinc
IEC 60575	Thermal Mechanical Endurance tests and Mechanical Endurance tests and Mechanical performance tests in string Insulator units
IEC 60672	Specification for Ceramic and Glass Insulating materials Part.I Definitions and classifications Part.II Methods and test
IS 731	Specification for porcelain insulators for over head lines (3.3 KV and above)
IS 814	Phosphor Bronze sheet, strip and foil

IS 1570	Specification for wrought steel for General Engineering purpose
IS 1573	Electroplated coatings of zinc on iron and steel
IS 2071 (Part 1 and 3)	Methods of High Voltage Testing
IS 14329	Malleable iron castings
IS 2486	Parts 1,2,3 and 4 specifications for insulator fittings for over head power lines with nominal voltage greater than 1000 volts
IS 2629	Recommended practice for hot dip galvanizing of Iron and Steel
IS 3188	Dimensions for disc insulators
IS 6603	Stainless steel bars and flats (Amendments 1 to 4)
IS 7811	Phosphor bronze rods and bars
IS 7814	Phosphor rods and bars
IS 8263	Method of radio interference tests on HV insulators
IS 8269	Method of switching impulse Test on HV insulators
IEC:60507	Salt Fog Pollution voltage withstand test.
IEC:60815	Guide for the selection of insulators in respect of polluted conditions.
ASTMC151-93- a	Standard Test Method for Autoclave Expansion of Portland Cement.
ANSIC29-2	American National Standard for Insulators wet process porcelain and toughened glass suspension type.
IEC:60437	Methods of RIV test of HV insulators
IEC:60372	Locking devices
IEC:60797	Residual strength of string insulator unit of glass or ceramic material for overhead line after mechanical damage of the dielectric
IEC : 60433	Insulators for overhead lines with a nominal voltage above 1000 V - Ceramic insulators for a.c. systems- Characteristics of insulator units of the long rod type.

3.3 Atmospheric Conditions: The materials offered shall be suitable for operation in tropical climate and will be subject to the full rays of the sun and inclement weather and should be able to withstand wide range of temperature variations. The humidity may be as high as 100% during rainy season and as low as 10% during the dry season.

3.4 Markings: Each insulator shall be legibly and indelibly marked to show the

following: -

(a) Name and trade mark of the manufacturer
(b) Month and year of manufacture
(c) Minimum failing load in kg
(d) Country of manufacture
(e) One 10 mm thick ring of suitable quality of paint shall be marked on the cap of each insulator of particular strength for easy identification of the type of insulator. Following codes shall be used as identification mark:

1. For 120 kN Disc Insulator/Long rod unit: - Orange
2. For 160 kN Disc Insulator/ Long rod unit: - Green

3.5 The hardware and accessories for porcelain insulator and conductor for 400 kV D/C overhead power line to be used in the project shall conform to the following codes of the Bureau of Indian Standards (BIS) and British Standards (BS), unless specifically stated otherwise in the Specification.

IS 209	Zinc Ingot- Specification (Fourth Revision with amendment no. 2)
IS 731	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 volts (second revision with amendments 1 to 5)
IS 1570	Schedules for wrought steels for general engineering purposes (Amendment No. 1 and 3)
IS 1570 (Part 1)	Steel specified by tensile and/or yield properties (first Revision) with amendment No.1)
IS 1573 (I Revision)	Electroplated coatings of zinc on iron and steel
IS 2002	Steel plates for pressure vessels for intermediate and high temperature.
IS 2004 (II Revision)	Carbon steel forging for general engineering purposes
IS 2121	Conductors and Earthwire accessories for overhead power lines.
IS 2121 (Part 1)	Armour rods, binding wires and tapes for conductors.
IS 2486	Insulator fittings for overhead power lines of 33 KV and above
IS 2486 (Part 1)	General requirements and tests (First revision with Amendment)
IS 2486 (Part 2)	Dimensional requirements (First revision)
IS 2486 (Part 3)	Locking Devices

IS 2486 (Part 5)	Tests for locking devices
IS 2633	Methods for testing uniformity of coating on zinc coated articles (First revision)
BS 3288 (Part 1)	Insulator and conductor fittings for overhead power lines - Performance and general requirements
BS 3288 (Part 2)	Specification for insulator and conductor fittings for overhead power lines - Dimensions
IS 4172	Dimensions for heads of bolts and screws
IS 4206	Dimensions for nominal lengths thread lengths for bolts, screws and studs (with Amendment No. 1)
IS 4218 (Part 1)	ISO General Purpose Metric Screw Threads - Part 1 : Basic and Design Profiles (Second Revision)
IS 4218 (Part 2)	SO General Purpose Metric Screw Threads - Part 2 : General Plan (Second Revision)
IS 4218 (Part 3)	ISO General Purpose Metric Screw Threads - Part 3 : Basic Dimensions (Second Revision)
IS 4218 (Part 4)	ISO General Purpose Metric Screw Threads - Part 4 : Selected Sizes for Screws, Bolts and Nuts (Second Revision)
IS 4759	Hot dip zinc coating on structural steel and other allied products (Third revision with amendment no. 1)
IS 5561	Electric Power Connectors
IS 6603	Stainless Steel, bars and flats (Amendments 1 to 4)
IS 6745	Methods for determination of mass of zinc coating on zinc coated iron and steel articles (with amendment No.5)
IS 8263	Methods for radio interference tests on high voltage insulators
IS 10162	Spacers and spacer dampers for twin horizontal bundle conductors (with amendment no. 1)
IS 10136	Code of practice for selection of disc insulator fittings for highest system voltages of 72.5 kV and above

SECTION 4

CONDUCTOR

4.1 ACSR conductor MOOSE shall be used as Power conductors on 400kV Double Circuit Transmission Lines. The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendment changes adopted and published, unless specifically stated otherwise in the Specification.

IS 209	Zinc Ingot- Specification (Fourth Revision with amendment no. 2)
BS 215: 1970	Aluminium conductors, steel reinforced
IS 398 (Part-1)	Specification for Aluminium Conductors for Overhead Transmission Purposes: Aluminium Stranded Conductors.
IS 398 (Part-2)	Aluminium conductors, galvanized steel reinforced
IS 398 (Part-5)	Aluminium conductors galvanized steel reinforced for Extra high voltage (400 kV and above)
IS 1521	Method of Tensile Testing of Steel Wire.
IS 1778	Reels and drums for bare conductors (First Revision)
IS 5484	EC grade aluminium rod produced by continuous casting and rolling (second revision with amendment no. 1)
IS 2629	Recommended practice for hot dip Galvanizing of Iron and Steel.
IS 2633	Methods of testing uniformity of Coating on Zinc Coated articles
IS 4826	Hot dipped Galvanised coating on round steel wires
IS 5484	EC grade Aluminium rod produced by continuous casting and rolling (second revision).
IS 6745	Methods of Determination of Weight of Zinc Coating on Zinc Coated Iron and Steel Articles.
IS 7623	Lithium base Grease for Industrial purposes (First Revision)
IS 8263	Method of Radio Interference tests on high voltage insulators.
IEC: 60888	Zinc Coated Steel Wires for Stranded Conductors
IEC 60889	Hard Drawn Aluminium Wires for Overhead Line Conductors.

4.2 The Power conductor accessories that are required shall be suitable for TWINMOOSE ACSR conductor and the ground wire conductor accessories and

hardware fittings that are required shall be suitable for 7/3.66mm GSS wire. The fittings and accessories of Power conductor and Ground wire shall comply in all respects with the latest edition of the following codes of the Bureau of Indian Standards (BIS) and British Standards (BS) or any other equivalent authoritative standard.

IS 209	Zinc Ingot- Specification
BS 970 (Part 1)	General Instruction and testing procedures specific requirements for carbon Manganese alloy and stainless steels.
IS 1327	Method of determination of mass of tin coating on Tinplate (Second revision)
IS 1363	Hexagon head bolts, screws and nuts
IS 1363 (Part 1)	Hexagon head bolts (Second Revision with Amendment No.1)
IS 1363 (Part 2)	Hexagon head screws (Second Revision with Amendment No.1)
IS 1363 (Part 3)	Hexagon head screws (Second Revision with Amendment No.1)
IS 1367	Technical supply conditions for threaded steel fasteners.
IS 1367(Part 1)	Technical supply conditions for threaded steel fasteners.
IS 1367(Part 2)	Product grades and tolerance (Second Revision)
IS 1367 (Part 3)	Mechanical properties and test methods for bolts screws and studs with full lead ability (Second revision)
IS 1573	Electroplated coatings of zinc on Iron and Steel (First revision)
IS 2004	Carbon steel forgings for general engineering purposes (Second Revision.)
IS 2121	Conductors and Earth wire accessories for overhead power lines
IS 2121 (Part 1)	Armour rods, binding wires and tapes for conductors
IS 2121 (Part 2)	Mid span joints and repair sleeves for conductors
IS 2486	Insulator fittings for overhead power lines of 3.3 KV and above
IS 2486 (Part 3)	General Requirements and tests (First Revision with Amendment No.1)
IS 2486 (Part 2)	Dimensional Requirements (First Revision)
IS 2486 (Part 3)	Locking devices
IS 2486 (Part 4)	Tests for locking devices
IS 2629	Recommended practice for hot dip galvanizing of Iron and
IS 2633	Methods of testing uniformity of coating on Zinc coated articles (First Revision)
IS 3138	Specification for Hexagonal Bolts and Nuts
IS 4218	Specification for Metric Screw Threads

IS 4826	Hot dipped galvanized coatings on round steel wires
IS 5318	Specification for Hot dip galvanized coating on fasteners
IS 6639	Hexagon bolts for steel structures (Amendments – 1 and 2)
IS 8263	Method of radio interference tests on high voltage insulators
IS 9708	Stockbridge vibration dampers for overhead power lines
IS 10162	Spacers and spacer dampers for twin horizontal bundle conductors

SECTION 5

GROUND WIRE

5.1 This Galvanized Steel Stranded ground wire of 7/3.66 mm size and 981 N/sq.mm quality (grade 3 as per IS 2141) for the purpose of earthing and protection of power transmission lines. The ground wire shall consist of standard galvanized steel wires. The GSS wire is to be used for the overhead protection of 400 kV Double circuit.

5.2 The ground wire shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS) and British Standard.

IS 279	Galvanized steel wire for telegraph and telephone purposes (third revision with amendment no. 2)
IS 209	Zinc Ingot- Specification
IS 398 (Part 2)	Aluminium conductors for overhead transmission purposes: Part 2 Aluminium conductors, galvanized steel reinforced (third revision with amendment no. 1)
IS 398 (Part 5)	Aluminium conductors for overhead transmission purposes: Part 5 Aluminium conductors - galvanized steel reinforced for extra high voltage (400 kV and above) (first revision with amendment no. 2)
IS 1608	Mechanical testing of metals - Tensile Testing (third revision)
IS 1755	Method of wrapping test of steel wires (first revision with amendment no. 1)
IS 1778	Reels and drums for Bare conductors (first revision with amendment no. 1)
IS 2141	Hot Dip Galvanized Stay Strand (fourth revision with amendment no. 1)
IS 2363	Glossary of terms relating to wire ropes (First Revision)
IS 2500 (Part 1)	Sampling Inspection Procedures - Part 1 : Attribute Sampling Plans Indexed by Acceptable Quality Limit (AQL) for Lot-by-Lot Inspection
IS 2629	Recommended practice for hot dip galvanizing of iron and steel
IS 2633	Method of testing uniformity of coating *on* zinc Coated articles
IS 4826	Hot dipped galvanized coatings on round steel wires (first revision with amendment No.1)
IS 3635	Methods of test for resistance of metallic electrical resistance
IS 5714	Method of measurement of resistivity of metallic materials
IS 6594	Technical supply conditions for steel wire rope and strands

IS: 6745	Method for determination of mass of zinc coating of zinc coated iron and steel articles (with amendment no. 5)
IEC:60888	Zinc coated steel wires for stranded conductors
IEC:60889	Hard drawn aluminium wire for overhead line conductors

SECTION 6

OPTICAL GROUND WIRE

6.1 The OPTICAL GROUND WIRE (OPGW) cable comprises a ground wire (containing aluminium and steel) with optical fibres in the core or first layer. The OPGW cable replaces the normal ground wires and therefore has to fulfill all the electrical and environmental requirements which affect the ground wire. The fittings, accessories to be supplied shall also be suitable for the OPGW type.

6.2 OPGW Cable: The OPGW cable construction shall comply with IEEE 1138 and IEC publication 61396. The cable construction shall conform to the applicable clauses of IEC 61089 related to stranded conductors and following electrical and mechanical characteristics of OPGW:

Everyday Tension: < 20% of UTS of OPGW

DC Resistance at 20 deg. C: < 1.0 Ohm/kM

Short circuit current: > 6.32 kA for 1.0 sec

6.3 All Dielectric Self- Supporting (ADSS) Cable: ADSS cable shall be used for inter connecting OPGW cable with the terminal gantry at the substation/power house/office. The ADSS cable including various clamps, terminals and accessories shall withstand aeolin vibrations and possible galloping and touching of the phase conductors. In order to reduce the possibility of mechanical failure, the erosion of the cable sheath due to “dry banding effect” shall be minimized.

6.4 Fibre Types : Dual-Window Single Mode (DWSM) optical fibres of 24 Nos. shall be provided in the cable. The fibres shall be entirely suitable for splicing by means of normal fusion splicing techniques. The fibre shall be manufactured from high grade silica and doped as necessary to provide the required transmission performance.

6.5 The chemical composition of the fibres shall be specially designed to minimize the effect of hydrogen on the transmission properties. The fibre cable life expectancy shall be at least 25 years.

6.6 The material shall conform to the following Indian/International Standards, which shall mean latest revisions, amendments/changes adopted and published unless otherwise specified herein.

Indian standard	Title	International standard
	The international Telecommunication Union (ITU-T) Recommendations	G.652, G.653
	International Electro-technical Commission (IEC) vocabulary	IEC:60050
	Optic Fibres, Part 1:General specification	IEC:60793-1
	Optic Fibre Cables, Part 1: Generic Specification	IEC:60794-1
	Aluminium-magnesium-silicon alloy wire for overhead line conductors	IEC:60104
	Aluminium-clad steel wires for electrical purposes	IEC:61232
	Fibre Optic Test Procedure Series	EIA-TIA-445 (FOTPs)
IS 2121	Specification for Conductor and Earthwire Accessories for Overhead Power lines	
	IEEE Standard construction of composite Fibre Optic overhead Ground wire (OPGW) for use on electric utility power lines.	IEEE:1138
IS 398	Aluminium conductors for overhead transmission purposes	IEC:60889
	Standard Colors for Color Identification and Coding	IEEE: 359A
	Color Coding for Fibre Optic Cables	IEEE: 598

6.7 In the event of the supply of material conforming to any standard other than standards listed above, the salient features of comparison shall be brought out and furnished along with the bid.

SECTION 7

ERECTION, TESTING AND COMMISSIONING

7.1 This section covers erection, testing and commissioning of the transmission lines, handling, transportation and distribution of all line materials to the respective work site.

7.2 Except where otherwise specified or implied, the erection, testing shall conform to the provisions of IS 5613 (Part 3, Section - 2).

7.3 The commissioning shall be carried out as per Manual on Commissioning procedure for Transmission lines, CBI&P Publication no. 292.

7.4 The Indian Standard Specifications mentioned below or equivalent International Standards shall be applicable to the materials and processes used in executing the works.

IS 383	Course and Fine Aggregates from Natural Sources for Concrete.
IS 1200	IS 1200 Method of Measurement of Building and Civil engineering Works (Relevant Parts)
IS 456	Plain and Reinforced Concrete - Code of Practice (third revision with amendment no. 4)
IS 2502	Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement.
IS 3043	Code of Practice for Earthing.
IS 3764	Safety Code for Excavation Work.
IS 4081	Safety Code of Blasting and Related Drilling Operation.
IS 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.
IS 1080	Code of Practice for Design and Construction of Shallow Foundations in Soils (other than Raft, Ring and Shell)
IS 1498	Classification and Identification of Soils for General Engineering Purposes.
IS 1892	Code of Practice for Subsurface Investigation for Foundation.
IS 1904	Code of Practice for Design and Construction of Foundation in Soils: General Requirements.

IS 2131	Method of Standard Penetration Test for Soils
IS 2132	Code of Practice for Thin Walled Tube Sampling of Soils.
IS 2720	Method of Test for Soils (Relevant Parts)
IS 2809	Glossary of Terms and Symbols Relating to Soil Engineering.
IS 2911	Code of Practice for Design and Construction of Pile Foundations (Relevant Parts)
IS 3025	Methods of sampling and test (physical and chemical) for water and wastewater (Relevant Parts)
IS 4078	Code of Practice for Indexing and Storage of Drill Cores.
IS 4434	Code of Practice for In-situ Vane Shear Test for Soils
IS 4453	Subsurface Exploration by Pits, Trenches, Drifts and Shafts - Code of Practice
IS 4464	Code of Practice for Presentation of Drilling Information and Core Description in Foundation Investigation
IS 4968 (Part 2)	Method for subsurface sounding for soils: Part 2 Dynamic method using cone and bentonite slurry
IS 5313	Guide for Core Drilling Observations
IS 6403	Code of Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.
IS 6926	Diamond Core Drilling - Site Investigation for River Valley Projects - Code of Practice (first revision)
IS 6935	Method of Determination of Water Level in a Bore Hole.
IS 7422	Symbols and Abbreviations for Use in Geological Maps, Sections and Subsurface Exploratory Logs (Relevant Parts)
IS 8009 (Part –1)	Code of practice for calculation of settlements of foundations: Part 1 Shallow foundations subjected to symmetrical static vertical loads (with amendment no. 3)
IS 8764	Method for Determination of Point Load Strength Index of Rocks.
IS 9143	Method for Determination of Unconfined Compressive Strength of Rock Materials.

IS 9179	Method of Preparation of Rock Specimen for Laboratory Testing.
IS 9259	Liquid limit apparatus for soils
IS 9640	Split spoon sampler
IS 10050	Method for determination of slake durability index of rocks
IS 11315 (Part-1)	Method for the quantitative description of discontinuities in rock masses: Part 1 Orientation

7.5 The crossings of roads, river, khuds/nallahs, power and communication lines, and railway tracks falling in the line route shall be carried out with the types of structures and at angles shall be indicated in profile sheets to be submitted for approval, ensuring that the minimum clearances at maximum temperature in still wind condition, after taking the effect of conductor creep and slack caused by the broken conductor in the adjoining span are not less than the relevant clearances.

7.6 The crossings of railway tracks, telecommunication lines and erection of lines in the vicinity of aerodromes shall in addition meet the requirements of the regulations/code listed below:

i. Regulation for Power line crossing of Railway tracks issued by the Ministry of Railways.

ii. Code of practice for crossings between power and telecommunication lines issued by P&T Department.

iii. Requirements for routing of overhead lines in the vicinity of Aerodromes laid down by the Director, General of Civil Aviation, Govt. of India.

7.7 Crossing of Public Utilities: The concessionaire shall give notice to the appropriate authorities and intimate the date and time when it proposes to carry out erection of the conductors and ground wires across power lines or telecommunication lines, public roads, waterway, Railway etc.

Part- B

SUBSTATIONS

SECTION 8

AIR INSULATED SUBSTATION (AIS)

8.1 Main Design Data

All the equipment and systems at the substation shall be designed to meet the climatic parameters and meteorological data specified in Section-1 of this Manual and other project parameters as specified below:

8.1.1 Overall Fault Level**:** Overall fault level shall not be less than 63kA for 3 seconds for 400kV system.

8.1.2 Degree of Protection**:** The degree of protection for enclosures of the control cabinets, junction boxes and marshalling boxes, panels etc. shall be as under:

(i) Installed outdoor: IP- 55
(ii) Installed indoor in air conditioned area: IP-31
(iii) Installed in covered area: IP-52
(iv) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.
(v) For LT switchgear (AC and DC distribution boards) : IP-52

8.1.3 General arrangement for equipments**:** The general arrangement and distances for equipments i.e. bay length, bay width etc. shall be maintained in accordance with the indicative Single Line Diagram (SLD) and General Electrical Layouts (GELO) drawings of the substation.

8.2 Major equipments

8.2.1 Power Transformers and Reactors: The Power Transformers as well as Auxiliary transformers and Reactors shall comply in all respects with the following codes of Bureau of Indian Standards (BIS), International Electrotechnical Commission (IEC) and British Standards (BS).

IS:2026 Part 1:2011	Power Transformer - General
IS:2026 Part 2:2010	Temperature rise

IS:2026 Part 3:2009	Insulation levels, dielectric tests and external clearances in air
IS:2026 Part 4:1997	Terminal markings, tappings and connections
IS:2026 Part 5:2011	Ability to withstand short circuit
IS:2026 Part 7:2009	Loading guide for oil - immersed Power Transformers
IS:2026 Part 8:2009	Application guide
IS:2026 Part 10:2009	Determination of sound levels
IEC 60076 Part 1 (2011-04)	General
IEC 60076 Part 2 (2011-02)	Temperature rise
IEC 60076 Part 3 (2013-07)	Insulation levels, dielectric tests and external clearances in air
IEC 60076 Part 4 (2002-06)	Guide to lightning impulse and switching impulse testing – Power Transformers and reactors
IEC 60076 Part 5 (2006-02)	Ability to withstand short circuit
IEC 60076 Part 6 (2007-12)	Reactors
IEC 60076 Part 7 (2005-12)	Power Transformer - Loading guide for oil-immersed Power Transformers
IEC 60076 Part 8 (1997-10)	Application guide
IEC 60076 Part 10 (2001-05)	Determination of sound levels
IEC 60076 Part 11 (2004-05)	Dry-type transformers
IEC 60076 Part 12 (2008-11)	Loading guide for dry - type Power Transformers
IEC 60076 Part 13 (2006-05)	Power Transformer - Protected liquid filled transformers
IEC 60076 Part 14 (2013-09)	Guide for the design and application of liquid-immersed Power Transformers using high-temperature insulation materials
IEC 60076 Part 15 (2008-02)	Gas-filled-type Power Transformers
IEC 60076 Part 16 (2011-08)	Power Transformer - Transformers for Wind Turbine applications
IEC 60076 Part 18 (2012-07)	Measurement of frequency response

IEC 60076 Part 19 (2013-03)	Rules for the determination of uncertainties in the measurement of losses in Power Transformers and reactors
IEC 60076 Part 21 (2011-12)	Standard requirements terminology and test code for step-voltage regulators
BS EN 60076 Part 1: 2011	Power Transformer-General
BS EN 60076 Part 2:2011	Temperature rise for liquid immersed transformer
BS EN 60076 Part 3:2013	Insulation levels dielectric tests and external clearances in air
BS EN 60076 Part 4 :2002	Guide to lightning impulse and switching impulse testing – Power Transformers and reactors
BS EN 60076 Part 5 :2006	Ability to withstand short circuit
BS EN 60076 Part 6:2008	Reactors
BS EN 60076 Part 7:2005	Loading guide for oil-immersed Power Transformers
BS EN 60076 Part 8 :1997	Application guide
BS EN 60076 Part 10: 2005	Determination of sound levels
BS EN 60076 Part 11:2004	Dry-type transformers
BS EN 60076 Part 12:2011	Loading guide for dry-type Power Transformers
BS EN 60076 Part 13:2006	Self protected liquid filled transformers
BS EN 60076 Part 14:2013	Liquid-immersed Power Transformers using high-temperature insulation materials
BS EN 60076 Part 16:2011	Transformers for Wind Turbine applications
BS EN 60076 Part 18:2012	Measurement of frequency response
IS:3639-1966 (reaffirmed 2001)	Specification for fitting and accessories for Power Transformers
BS EN :1014 Part-1:2010	Wood preservatives. Creosote and creosoted timber. Methods of sampling and analysis. Procedure for sampling creosote
BS EN :1014 Part-2:2010	Wood preservatives. Creosote and creosoted timber. Methods of sampling and analysis. Procedure for obtaining a sample of creosote from creosoted timber for subsequent analysis
BS EN :1014 Part-3:2010	Wood preservatives. Creosote and creosoted timber. Methods of sampling and analysis. Determination of the benzo(a)

	pyrene content of creosote
BS EN :1014 Part-4:2010	Wood preservatives. Creosote and creosoted timber. Methods of sampling and analysis. Determination of the water-extractable phenols content of creosote
IS 6600-1972 (reaffirmed 2001)	Guide for loading of oil-immersed transformer
IS:335: 1993 (reaffirmed 2005)	New insulating oils- specification
BS :148 2009	Reclaimed mineral insulating oil for transformers and switchgear specification
BS :148 Part -1: 2010	Metallic materials. Charpy pendulum impact test. Test method
BS :148 Part -2:2008	Metallic materials. Charpy pendulum impact test. Verification of testing machines
BS :148 Part -3:2008	Metallic materials. Charpy pendulum impact test. Preparation and characterization of Charpy V-notch test pieces for indirect verification of pendulum impact machines
IEC: 60296	Fluids for electro-technical applications. Unused mineral insulating oils for transformers and switchgear
IS:2099:1986 (reaffirmed 2003)	Bushings for alternating voltages above 1000 volts
IEC 60137: 2003-2008	Insulated bushings for alternating voltages above 1000v
IS:3637-1966 (reaffirmed 2007)	Specification for gas -operated relays

8.2.2 Circuit Breakers: The duty cycle of Circuit Breakers installed in 420 / 245 / 145 kV System shall be "O-0.3 sec-CO-3 min-CO". The Surge Arrester shall be suitable for such circuit breaker duties in the system. Circuit Breakers shall have the following parameters:

Voltage level	400 kV	220 kV	132 kV
Break Time (ms)	40	50	60
Auto reclosing	Single/Three Phase	Single/Three Phase	Three Phase

The Circuit Breakers shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS) and International Electrotechnical Commission (IEC):

IS 13118: 1991 (reaffirmed 2002)	Specification for high voltage alternating current circuit breaker

IEC 62271-100:2012	High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
IS 2544-1973 (reaffirmed 2006)	Porcelain post insulator for system with nominal voltages greater than 1000 volt
IEC 60273:1990	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 2099:1986 (reaffirmed 2003)	Specification for bushing for above alternating voltages above 1000 volts
IS 5621-1980	Specification for hollow insulators for use in electrical equipment
IS 5561-1970 (reaffirmed 2002)	Specification for electric power connectors
IS 2629-1985 (reaffirmed 1994)	Recommended practice for hot- dip galvanizing and steel
IS 2633- 1986 (reaffirmed 2006)	Method for testing uniformity of coating on zinc coated articles
IS 9135- 1979 (reaffirmed 2002)	Guide for testing of circuit breakers with respect to out-of-phase switching
IEC 60376	Specification of technical grade sulfur hexafluoride(SF6) for use in electrical equipment

8.2.3 Disconnectors and Earthing Switches: Disconnectors for 132 kV, 220 kV and 400 kV rating shall have provision for remote and manual operation. Earthing switches shall be provided at appropriate locations to facilitate earthing of outgoing transmission lines/equipment to enable maintenance. Only local operation is recommended for earth switches. The Disconnectors and Earthing Switches shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS) and International Electrotechnical Commission (IEC):

IS 9921 Part 1-1981	Specifications for alternating current disconnectors (isolators) and earthing switches for voltages above 1000V - General and definitions
IS 9921 Part2-1982	Specifications for alternating current disconnectors (isolators) and earthing switches for voltages above 1000V - Rating
IS 9921 Part3-1982	Specifications for alternating current disconnectors (isolators) and earthing switches for voltages above 1000V - Design and construction
IS 9921 Part4-1985	Specifications for alternating current disconnectors (isolators) and earthing switches for voltages above 1000V -

	type test and routine test
IEC 60694	Common specifications for high voltage switchgear and control gear standards
IEC 6227-102	High voltage switchgear and control gear- Part 102: Alternating current disconnectors and earthing switches
IS 2544-1973 (reaffirmed 2006)	Porcelain post insulator for system with nominal voltages greater than 1000 volt
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 5561-1970 (reaffirmed 2002)	Specifications for electric power connectors
IS 2629-1985 (reaffirmed 1994)	Recommended practice for hot- dip galvanizing and steel
IS 2633- 1986 (reaffirmed 2006)	Method for testing uniformity of coating on zinc coated articles

8.2.4 Current Transformers: The rated currents and ratios, the number of secondary winding (protection and 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 winding shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and operation of Meters) Regulations, 2010.

The Current Transformer shall comply in all respects with the following codes of Bureau of Indian Standards (BIS), International Electro technical Commission (IEC) and British Standard (BS) specifications:

IS 2705 Part1: 1992	Current transformers specifications - General requirement
IS 2705 Part2:1992	Current transformers specifications - Measuring current transformers
IS 2705 Part3:1992	Current transformers specifications - Protective current transformers
IS 2705 Part4:1992	Current transformers specifications - Protective current transformer for special purpose applications
BS EN 61869 Part1	Instrument transformers: General requirements

BS EN 61869 Part2	Instrument transformers: Additional requirements for current transformers
BS EN 61869 Part4	Instrument transformers: Additional requirements for combined transformers
IS:335: 1993 (reaffirmed 2005)	New insulating oils - specifications
IEC: 60296 2003-11	Fluids for electro-technical applications - Unused mineral insulating oils for transformers and switchgear
IS 2099:1986 (reaffirmed 2003)	Specification for bushing for above alternating voltages above 1000 volts
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IS 5621-1980	Specification for hollow insulators for use in electrical equipment
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IS 2544-1973 (reaffirmed 2006)	Porcelain post insulator for system with nominal voltages greater than 1000 volt
BS 3297 Part1	Post Insulators of Ceramic Material or Glass for Nominal Voltages Greater Than 1000 V Part 1: Methods of Test
BS 3297 Part2	Characteristics of Indoor and Outdoor Post Insulators for Systems with Nominal Voltages Greater than 1000 V
BS 3297 Part3	Post Insulators of Ceramic Material or Glass for Nominal Voltages Greater Than 1000 V Part 3: Guide to Insulator Practice
IEC 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
IS 2629-1985 (reaffirmed 1994)	Recommended practice for hot- dip galvanizing and steel
IS 2633- 1986 (reaffirmed 2006)	Method for testing uniformity of coating on zinc coated articles

8.2.5 Voltage/Capacitor Voltage Transformers: The number of secondary winding (protection or metering), accuracy class and burden shall be in accordance with the requirements of the protection system. The accuracy class for metering winding

shall be equal to or better than the accuracy class of the meter specified in the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2010. The capacitance of CVT shall match the PLCC requirements.

The Voltage/Capacitor Voltage Transformer shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS), British Standards (BS) and International Electrotechnical Commission (IEC):

IS 3156 Part 1	Voltage transformer specifications - General requirements
IS 3156 Part2	Voltage transformer specifications -Measuring voltage transformer
IS 3156 Part 3	Voltage transformer specifications -Protective voltage transformer
IS 3156 Part 4	Voltage transformer specifications -Capacitive voltage transformer
BS EN 61869-Part3	Instrument transformers. Additional requirements for inductive voltage transformers
BS EN 61869-Part 4	Instrument transformers - Additional requirements for combined transformers
BS EN 61869-Part5	Instrument transformers - Additional requirements for capacitor voltage transformers
IS 9859 Part1	Code and practice for installation and maintenance of outdoor power line carrier equipment -Line trap
IS 9859 Part2	Code and practice for installation and maintenance of outdoor power line carrier equipment -Coupling devices
IS 9859 Part3	Code and practice for installation and maintenance of outdoor power line carrier equipment -Coupling capacitor/capacitor voltage transformer

8.2.6 Surge Arresters: Station class, heavy duty, gapless metal oxide (ZnO) type Surge Arresters shall be provided. The rated voltage, minimum Continuous Operating Voltage (COV), energy handling capability, nominal discharge current and other characteristics of a Surge Arrester shall be chosen in accordance with power

system requirements. Surge Arresters shall be provided at locations as per General Electrical Layout (GELO). A leakage current monitor with surge counter shall be provided with each surge arrester.

The Surge Arresters shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS) and International Electrotechnical Commission (IEC):

IS 3070 Part3	Lightning arrester for alternating current system specifications - Metal oxide lightning arrester without gaps
IEC 60099-Part4	Surge Arresters - Part 4: Metal-oxide surge arresters without gaps for a.c. systems
IEC 60099-Part5	Surge Arresters - Selection and application recommendations
IEC 60099-Part6	Surge Arresters containing both series and parallel gapped structures- rated 52kV and less
IEC 60099-Part8	Surge Arresters - Metal-oxide surge arresters with external series gap (EGLA) for overhead transmission and distribution lines of a.c. systems above 1 kV
IEC 60099-Part9	Surge Arresters - Metal-oxide surge arresters without gaps for HVDC converter stations
IS 2544-1973 (reaffirmed 2006)	Porcelain post insulator for system with nominal voltages greater than 1000 volt
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IS 5621-1980	Specifications for hollow insulators for use in electrical equipment
IEC 62155	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1000 V
IS 5561-1970 (reaffirmed 2002)	Specifications for electric power connectors
IS 2629-1985 (reaffirmed 1994)	Recommended practice for hot- dip galvanizing and steel
IS 2633- 1986 (reaffirmed 2006)	Method for testing uniformity of coating on zinc coated articles

8.2.7 Line Trap: A line trap is intended for insertion in a high voltage power transmission line between the point of connection of carrier frequency signals and adjacent power system elements such as bus bars, transformers etc.

The Line Trap shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS), British Standards (BS) and International Electrotechnical Commission (IEC):

IS:8792	Line traps for power systems-specification
BS 4996	Specification for Line traps for power line carrier systems
IEC:60353	Line trap for AC power system
IS:8793	Line traps for AC power systems- methods of tests

8.3 System

8.3.1 Auxiliary supply: AC and DC distribution system shall be so designed as to meet the requirement of the substation in accordance with the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Amended Regulations, 2013. Computation of capacity of battery set in attended substations or switchyards shall be as given bellow:

	Where standby battery is provided (in hours)	Where standby battery is not provided (in hours)
Steady and continuous load	3	6
Emergency lighting loads	1	2

8.3.2 Support structure / Ground clearance: All the support structures shall be galvanized as per the relevant codes and standards. Minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad, shall be as per IE Rules.

8.3.3 Clamps, terminals and connectors: All equipments shall be supplied with the

necessary clamps and connectors, as required by the ultimate design of a particular installation. All clamps and connectors shall conform to IS: 5561 and NEMA CC-1.

8.3.4 Bus bar: Minimum Bus-Bar capacity (Ampacity) for 400 kV and 220 kV shall be as mentioned in indicative Single Line Diagram (SLD). The switching schemes shall be adopted as detailed in the indicative General Electrical Layout (GELO).

8.3.5 Control cabinets, junction, terminal and marshalling boxes: All types of marshalling and junction boxes, cabinets etc. shall generally conform to and be tested in accordance with IS-5039 / IS:8623, IEC-439, as applicable. They shall be dust, water and vermin proof and made of sheet steel or aluminum enclosure properly braced to prevent wobbling. Sheet steel to be used shall be at least 2.0 mm thick cold rolled or 2.5 mm hot rolled. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life compared to sheet steel of specified thickness.

The control cabinets, junction boxes and marshalling boxes shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS), International Electrotechnical Commission (IEC) and British Standards (BS):

IS/IEC 60947-1 Part 1	Low-Voltage Switchgear And Control gear - General Rules
IS/IEC 60947-1 Part 2	Low-Voltage Switchgear And Control gear - Circuit breaker
BS EN-60947 Part2	Low-Voltage Switchgear And Control gear - Circuit breaker
BS EN-60947 Part3	Switches disconnectors switch - disconnectors and fuse-combination units
BS EN-60947 Part4-1	Contactors and motor-starters. Electromechanical contactors and motor-starters
IS 8623 Part1	Specification for low voltage switchgear and control gear assemblies - Requirement for type tested and partially type tested assemblies
IS 8623 Part2	Particular requirements for bus bar trunking systems (bus ways)

BS EN 61439-1	Low-voltage switchgear and control gear assemblies. General rules
BS EN 61439-2	Low-voltage switchgear and control gear assemblies. Power switchgear and control gear assemblies
BS EN 61439-3	Low-voltage switchgear and control gear assemblies. Distribution boards intended to be operated by ordinary persons (DBO)
BS EN 61439-4	Low-voltage switchgear and control gear assemblies. Particular requirements for assemblies for construction sites (ACS)
BS EN 61439-5	Low-voltage switchgear and control gear assemblies. Assemblies for power distribution in public networks
IEC 62598	Nuclear instrumentation - Constructional requirements and classification of radiometric gauges
IS/IEC 60898-1	Electrical Accessories - Circuit-breakers for over current protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation
IS/IEC 60898-2	Circuit-breakers for over current protection for household and similar installations
	Specification for low voltage fuses for voltages not exceeding 1000V ac or 15000V dc
IS-13703 Part1	General requirement
IS-13703 Part2-1	Supplementary requirement.
IS-13703 Part2-2	Fuses for use by authorized fuses
IEC-60269-1 Part1	Low-voltage fuses –General requirements
IEC-60269-1 Part 2	Low-voltage fuses - Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) - Examples of standardized systems of fuses A to K
IS-8187	Specification for D type fuses

BS-775 Part1	Multichannel stereophonic sound system with and without accompanying picture
BS-775 Part 2	Multichannel stereophonic sound system with and without accompanying picture
BS-775 Part3	Multichannel stereophonic sound system with and without accompanying picture
IEC-947-4-1 Part1	Low-voltage switchgear and control gear - Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
IEC-947-4-2 Part 2	Low-voltage switchgear and control gear - Part 4-2: Contactors and motor-starters - AC semiconductor motor controllers and starters
IS-3231 Part1.1	Specification for electrical relays for power system protection
IS-3231 Part1. 2	Insulation tests
IS-3231 Part2	Requirements for principal families
IS-3231 Part3	Requirements for particular group of relays
IEC-60255 Part1-Part27	Measuring relays and protection equipment
IS-1248 Part1- Part9	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC-60051	Direct acting indicating analogue electrical measuring instruments and their accessories
IS-5578	Guide for making insulated conductors
IS-11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
BS-159	Specification for high-voltage bus bars and bus bar connections
IS-722	AC Electricity Meters

BS-5685	Electricity meters. Specification for Class 0.5 1 and 2 single-phase and poly phase single rate and multi-rate watt-hour meters (Obsolescent but remains current)
IS-10118	Code of Practice for selection installation and maintenance of Switchgear and Control gear
IS-6005	Code and practice for phosphate coatings of iron and steel
BS 3189	Phosphate conversion coatings for metals
IS-5082	Wrought aluminium and aluminium alloy bars rods tubes sections plates and sheets for electrical applications
IEC-60114	Recommendation for heat-treated aluminium alloy bus bar material of the aluminium-magnesium-silicon type

8.3.6 Bushings, hollow column insulators, support insulators: Bushings shall be manufactured and tested in accordance with IS: 2099 and IEC:60137.

Hollow column insulators shall be in accordance with IEC-60233 / IS: 5621 and support insulators as per IS: 2544 / IEC-60168, IEC-60273 and IEC-60815 as applicable. Composite silicon insulators, conforming to IEC-61109 may also be used.

All iron parts of insulators and bushings shall be hot dip galvanized and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator / bushing design shall be such as to ensure a uniform compressive pressure on the joints.

8.4 Sub System

8.4.1 Substation automation system (SAS): The Substation Automation System (SAS) shall be installed to control and monitor all the substation equipment from Remote Control Centre (RCC) as well as from Local Control Centre (LCC).

(i) The SAS shall contain the following main functional parts:
(a) Bay control Intelligent Electronic Devices (IED s) 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 (IEDs) 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 (IEDs) for protection and control shall provide the direct connection to the switchgear without the need of interposing components/wiring and perform control, protection, and monitoring functions.

8.4.2 Power line communication and protection of transmission system: The power line tele-communication and protection equipment shall be provided at both ends of all the Transmission Lines.

(a) Communication

(i) Frequency Planning: For planning frequency and output power of carrier terminals, the minimum signal to noise ratio of 25 dB for the speech channels without companders shall be adopted.

(ii) Proposed Arrangement: The power line tele-communication and tele-protection equipment shall provide secure and reliable information link for speech communication, data transfer, distance protection and direct tripping of remote-end breakers.

(b) Protection

(i) Protective Relaying System: Adequately sectionalized and graded protective relaying system shall be provided for transmission lines, transformers and bus bars so as to automatically isolate the faulty equipment. All main protection relays shall be of numerical type and communication protocol shall conform to IEC-61850.

(ii) Grouping of Protection: The protection functions shall be subdivided into two groups each being independent and capable of providing uninterrupted

protection even in the event of one of the protection groups failing. Grouping shall be done to the extent possible in such a way that each group can independently carry out protective functions with near equal redundancy. Interconnection between these two groups shall not generally be attempted.

(iii) Guidelines: The protection in respect of Transmission Lines, Power Transformers, Circuit Breakers, Bus-bars and other provisions shall be as per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulation 2010 and CBI&P guidelines on Protection.

(iv) Bus bar Protection and Local Breaker Backup Protection: Duplicate Bus bar protection for 400 kV, single bus-bar protection for 220 kV systems and local breaker backup protection for 400 kV and 220 kV shall be provided. The bus bar protection scheme shall have provision for future expansion and space planning for the same shall be done at project planning stage itself.

(v) Disturbance Recorders, Event Loggers and Time Synchronization Equipment: Each line shall be provided with facility for disturbance recording, distance to fault locator and Time Synchronizing Equipment (TSE). TSE complete with antenna, all cables, processing equipment etc., shall be provided to receive synchronizing pulse through GPS compatible for synchronization of event logger, disturbance recorder and SCADA/automation system of the sub- station or switchyard.

The Power Line Tele-Communication and Tele-Protection Equipment shall comply with the following codes of Bureau of Indian Standards (BIS):

IS 9859 Part1	Code and practice for installation and maintenance of outdoor power line carrier equipment -Line trap
IS 9859 Part2	Code and practice for installation and maintenance of outdoor power line carrier equipment -Coupling devices
IS 9859 Part3	Code and practice for installation and maintenance of outdoor power line carrier equipment -Coupling capacitor/capacitor voltage transformer

8.4.3 Inter utility metering system: The Energy Metering System as specified in CEA (Installation and Operation of Meters) Regulations, 2006 dealing with installation

and operation of meters including interface meters shall be used for tariff metering for bulk inter- utility power flows in the Grid system. The metering system shall be installed on each circuit as a self contained device for recording and measurement of active energy and reactive energy in each successive 15-minute block including other functions as described in the CEA's Notification referred above.

8.5 Substation and switchyard support facilities

8.5.1 Illumination and Lighting: The Concessionaire shall design, provide and maintain at all times a good indoor and outdoor lighting and illumination system in a substation both for normal and emergency situations to ensure safety of the working personnel.

The illumination levels and lighting systems shall comply with the following codes of the Bureau of Indian Standards (BIS) and CBI&P:

IS 3646 Part 1 and 2	Principles of good lighting and aspects of designs, code of practice
IS 3646 Part 3	Code of practice for interior illumination.
CBI&P	CBI&P Manual on Substation Layout Publication No. 299

8.5.2 Earthing System: The earthing system shall be designed to protect equipments and human life against excessive touch voltages in fault conditions and to keep transferred potential to minimum.

As per IEEE 80, the acceptable value of effective resistance of earthing grid considered is less than 1 Ω. The parameters associated with ground gradients viz., GPR, touch and step potentials shall be within acceptable limits.

The earthing systems shall comply in all respects with the following codes of the Bureau of Indian Standards (BIS), Institute of Electrical and Electronics Engineers (IEEE) and CBI&P:

IEEE 80-2000	Guide for Safety for AC Substation Grounding
CBIP	CBIP Manual on earthing of AC Power Systems, Publication no.302
IS 3043	Indian standard for code of practice for earthing

8.5.3 Fire Protection System: The fire detection, alarm and protection system for substation and switchyard shall be provided as per CEA (Construction of Electrical Plants and Electric Lines) Regulations 2010.

8.5.4 Air Conditioning System: Air Conditioning (AC) requirement shall be met using individual split AC units. AC units for control room building shall maintain DBT 24.40^0 C +/- 2^0 C. The following facilities shall be air conditioned:

(a) Control room;
(b) Engineer's room;
(c) Battery room;
(d) Electronics test lab; and
(e) Conference Room.

8.5.5 Oil evacuation, filtering, testing and filling apparatus: To monitor the quality of oil for satisfactory performance of transformers, shunt reactors and other oil filled equipments, and for periodical maintenance, necessary oil evacuation, filtering, testing and filling apparatus shall be provided at the substation. Oil tanks of adequate capacities for storage of pure and impure transformer oil shall also be provided.

8.5.6 SF6 filling, evacuation, filtering, drying and recycling plant: SF6 filling, evacuation, filtering, drying and recycling plant with adequate storage capacity shall be provided at the substation along with trolley for filling or evacuation of SF6 gas circuit breaker and to monitor the purity, moisture content, decomposition product etc. of SF6 gas.

8.6 Mandatory initial spares, tools and tackles

Mandatory spares shall be kept in stores as per the CERC / SERC guidelines and good Industry Practice. The inventory of spare parts shall at all times be maintained by replenishing in case any item is utilized during construction and commissioning or operation and maintenance.

SECTION 9

GAS INSULATED SUBSTATION (GIS)

9.1 General

9.1.1 Gas insulated substation comprising of operating devices, accessories and auxiliary equipment shall be metal-enclosed SF6 gas type as per IEC 62271-203. The GIS shall be indoor/ outdoor type.

9.1.2 400kV GIS system, shall be single phase type. 220/132kV GIS system shall be three phase or single phase or a mixture of both. 33kV GIS shall be three phase type.

9.1.3 The arrangement of gas sections/compartments shall be such as to facilitate future extension of any make on either end without drilling, cutting or welding on the existing GIS. It shall not be necessary to move or dislocate the existing substation bays for adding the equipment. GIS shall be totally safe against inadvertent touch of any of its live parts. It shall be protected against all types of voltage surges.

9.1.4 GIS shall include all the necessary equipment/accessories for satisfactory operation and erection of the GIS substation. The ladders and walkways shall be provided wherever necessary for access to the equipment.

9.2 Constructional requirements

9.2.1 The material and thickness of the enclosures shall withstand the internal flash over without burn through at rated fault current for a period as per IEC 62271-203.

9.2.2 Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable codes and pressure vessel shall be based on the design temperature and pressures as per relevant IEC. The maximum gas leakage for GIS shall not be more than 0.5% of iterated pressure per year.

9.2.3 The fabricated metal enclosures shall be of non-magnetic material with high resistance to corrosion, low electrical losses and negligible magnetic losses.

9.2.4 The disconnecting switches and earth switches shall preferably be provided with windows to inspect switch contact positions directly.

9.2.5 Enclosures shall be single phase/three phase (as applicable) encapsulation for bus bars and feeder section bays. The substation shall be modular in design with provision of future extensions.

9.3 Major equipments

9.3.1 Circuit Breaker: Circuit breaker (CB) shall be of SF6 gas insulated single phase/ three phase (as applicable) type. It shall be self blast /puffer type and consist of one interrupting chamber upto 245kV, two interrupting chambers upto 400kV and maximum four interrupting chamber upto 765kV

The arrangement shall be horizontal/vertical as per manufacturer preferred layout considering space limitation and taking into account the worst service conditions/forces imposed by earth quake. The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. The removed interrupter assembly must be easily and safely accessible for inspection and possible repairs.

Refer Part B, Section 8, Clause 8.2.2 of the manual for details and standards.

9.3.2 Disconnectors (isolators) and earth switches: Disconnectors shall be single pole, group control with motor operated mechanism as per IEC 62271-102. The provision of emergency manual operation shall also be included.

Earth switch shall be provided with manual operating mechanism as per IEC-62271-102. M otor operated mechanism shall be provided with electrical control from local position. Safety interlocks shall be provided for closing of earth switch when disconnector is open and vice versa.

The following points shall be noted in case of fast acting earthing switches:

(i) Fast acting earthing switches as per IEC 62271-102, located on the line side of feeder bay module shall be of three-pole, group operated, high speed make- proof type to discharge the charging currents in addition to

their safety grounding function. It shall interrupt inductive currents and withstand transient recovery voltage (TRV) also.

(ii) The Short Circuit Making Current of earth switch shall be at least equal to its peak withstand current rating. The switches shall have electrostatic and electromagnetic induced current switching capability also.

(iii) Earthing switch shall be provided with clearly identifiable local positive driven mechanical indicator and position indicator on the bay module control cabinet and provision for remote signaling.

(iv) Earthing switch operation shall be possible by local control cabinet or remote control room in addition to opening of the associated disconnector.

Refer Part B, Section 8, Clause 8.2.3 of the manual for details and standards.

9.3.3 Current Transformer: Current transformer (CT) and its accessories for protection and metering as per IEC 60044-1 shall be incorporated into the GIS and shall be of metal enclosed type. The secondary windings shall be air-insulated and mounted inside separate metal enclosure. CT shall be provided with effective electromagnetic shields to protect against high frequency transients typically 1-30MHz. CT burden shall not be less than 10VA to achieve required 0.2S accuracy class.

Refer Part B, Section 8, Clause 8.2.4 of the manual for details and standards.

9.3.4 Voltage Transformer: Voltage transformers (VT) shall be of the electromagnetic type with SF6 gas insulation as per IEC 60044-2. VT shall be located in a separate module and will be connected phase to ground. Effective shielding against high frequency electromagnetic transients shall be provided. The VT burden for metering class winding shall not be less than 50VA to achieve 0.2S accuracy class.

Refer Part B, Section 8, Clause 8.2.5 of the manual for details and standards.

9.3.5 Outdoor Bushings: Porcelain bushings shall conform to IEC 60137. SF6 to air bushing shall be of ceramic insulator and pressurized with SF6 gas. The conductor

shall be supported by the insulator cone at the switchgear end and the high-voltage electrode at the air end.

9.3.6 Surge Arrestors: Surge arrestors (SA) with counter shall be outdoor air insulated/SF6 gas insulated metal oxide and gapless type as per IEC 60099-4. The metal housing of SF6 gas insulated SA shall be connected to the metal enclosure of the GIS with a flanged, bolted and gasket joint so that the arrester housing is grounded through the GIS enclosure. The ground connection shall be sized for GIS fault level.

The detailed system studies and calculations including insulation co-ordination shall be carried out before evolving the required parameters, locations, energy capabilities etc. of SA.

Refer Part B, Section 8, Clause 8.2.6 of the manual for details and standards.

9.4 Sub-Systems

9.4.1 Gas insulated Bus duct: The components of GIS including transformers shall be connected by SF6 insulated bus consisting of an inner conductor and outer enclosure.

9.4.2 HV Power cable connection: The cable end box shall be as per relevant IEC. The final connection of the high voltage cable circuits in GIS shall be with single-phase cables. All cable end modules shall be suitable for connecting single core, XLPE solid dielectric cable or low pressure oil filled cable type.

Transformer shall be connected to GIS outgoing bus duct using complete enclosed adapters. The transformer bushing housing shall be as per IEC 61639. The adapter shall have a removable bus link to allow electrically disconnecting the transformer from the bus, for testing of the bus/ transformer separately and removal of the transformer, if required.

9.4.3 Gas system:

(i) GIS shall be provided with adequate SF6 gas to pressurize the complete system. One zone/ compartment shall be pressurized to the rated nominal gas density.

(ii) The rated pressure of SF6 gas in GIS equipment shall be as low as possible, while still meeting the requirements for electrical

insulation and space limitations to reduce the effects of leaks and to ensure that there is no chance of the gas liquefying at the lowest ambient temperature.

(iii) SF6 gas shall be as per IEC 60376. Certificate of poison inspection shall be provided with supplied gas.

(iv) Self sealing vacuum couplings shall be provided on all gas compartments to facilitate filling and recharging.

(v) Gas filling and evacuating plant shall be provided necessary for filling-in/evacuating SF6 gas from GIS. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas. The capacity of temporary storage facilities shall be sufficient for storing the maximum quantity of gas that may be evacuated during maintenance/repair work of atleast one complete bay of GIS.

9.4.4 Local control cubicle: Local control cubicles shall be provided for control and interlocking, local operation of various equipments and indicating and measuring equipment for each bay/module.

9.4.5 GIS earthing:

(i) GIS shall be provided with provisions consisting of grounding pads to connect with the ground mat riser near the equipment.

(ii) The earthing system shall be based on multi-point design ensuring the protection in case of indirect contact (touch or step voltages, in case of fault) - and transient phenomena in case of lightning or switching operations.

(iii) The three enclosures of single phase GIS shall be bonded at the ends of GIS to neutralize the flow of circulating currents. All wirings to GIS shall be shielded and grounded.

(iv) The enclosure of GIS shall be adequately grounded to limit the potential difference between individual sections within allowable limit of 65-130V during faults.

(v) Earthing conductors shall withstand rated short circuit current. Conductors with copper bars shall be preferred over copper wires. Separate ground strips to short circuit flanges and earthing switches shall not be provided.

9.4.6 GIS Foundation Grounding:. A simple monolithic concrete steel reinforced slab

shall be provided to serve both as auxiliary grounding device and for seismic reasons. Concrete foundations may cause irregularities in current discharge path in gas insulated substations.

9.4.7 Monitoring system:

(i) Dew point meter: Portable Dew point meter for measuring the dew point of SF6 gas of CB/GIS shall be provided and adequately protected for outdoor use. The meter shall be provided with dew point hygrometer with digital indication to display the dew point temperature in Celsius or Fahrenheit or PPM. It shall be capable of measuring the corresponding pressure at which dew point is being measured.

(ii) Partial discharge monitoring system: The equipment shall be used for detecting different type of defects in GIS viz particles, loose shields and partial discharges. The instrument shall also be able to detect partial discharges in cable joints, terminations, CT and PT etc.

9.5 International/ Indian Standards

The GIS shall comply in all respects to the following codes of the Bureau of Indian Standards (BIS), International Electrotechnical Commission (IEC),British Standard (BS), Institute of Electrical and Electronics Engineers (IEEE) and European Standards (EN):

STANDARD REFERENCE	TITLE
IEC-60050	International electro-technical vocabulary
IEC-62271-203	High voltage alternating current circuit breakers
IEC-62271-203	Gas-insulated metal-enclosed switchgear for rated voltages 52 kV and above
IEC-60060	High voltage test techniques
IEC-60114	Recommendation for heat treated aluminium alloy bus bar material of the aluminium-magnesium-silicon type
IEC-62271-102	Alternating current disconnect switches and grounding switches

IEC-60137	Bushing for alternating voltages above 1000 volts
IEC-60044-1	Instrument transformers part 1: current transformers
IEC-60044-6	Requirements for protective current transformers for transient performance
IEC-60044-2	Instrument transformers part 2: inductive voltage transformers
IEC-60255	Electrical relays
IEC-60269	Low voltage fuses
IEC-60292	Low voltage motor starters
IEC-60376	Specification and acceptance of new sulphur hexafloride.
IEC-60376 A and B	First and second supplement to IEC pub-376 (1971)
IEC-60427	Synthetic testing of high voltage alternating current circuit breakers
IEC-60480	Guide for checking sf-6 gas taken from electrical equipment
IEC-60507	Artificial pollution test on hv insulators to be used on ac system
IEC 61639	Direct connections between Power Transformers and gas insulated metal-enclosed switchgear for rated voltages 72.5kv and above
IEC-60529	Classification of degree of protection provided by enclosures
IEC-60694	Common clauses for hv switchgear and control gear standards
IEC-60932	Additional requirement for enclosed switchgear and control gear from 1 kv to 72.5 kv for use in severe climate conditions
IEC-60815	Guide for selection of insulators in respect of polluted conditions
IEC-61259	Gas insulated metal – enclosed switchgear for rated voltages 72.5 kv and above – requirements for switching of bus charging circuit by disconnect switches
BS-5045-1	Specification for transportable gas containers. Seamless steel containers.
IEEE STD. 80	Ieee guide for safety in ac substation grounding

ANSI/IEEE C37.122	Standard for gas insulated substations
ISO-9003	Quality systems – model for quality assurance in final inspection and test
EN-50052	European standard – cast aluminium alloy enclosures for gas filled high voltage switchgear and control gear
EN-50064	Wrought aluminium and aluminium alloy enclosure for gas filled high voltage switchgear and control gear
EN-50069	Welded composite enclosures of cast and wrought aluminium alloys for gas filled high voltage switchgear and control gear
IEC-60859	Cable connection for GIS
ANSI/IEEE 1291	Guide for partial discharge measurements in power switchgear
IEC-60099-5	Surge arresters-part 5: selection and application recommendations
IEC-60099-4	Surge arresters-part 4: metal-oxide surge arresters without gaps for ac systems

SECTION 10

CIVIL WORKS

10.1 General

All structures, buildings, foundations, layout and other details shall be designed and developed keeping in view the functional requirement of the transmission line and substation and shall conform to the National Building code, relevant codes of IRC and Good Industry Practice:

10.2 Roads, culverts, PCC Pavement and Parking

All internal roads, culverts, PCC pavements and parking within the substation area and approach road from the main road to the substation shall be constructed as per Rajasthan PWD specifications and as per layout in the GELO / CLO of the substations.

10.3 Fire Protection Walls

Fire protection walls in order to protect against the effects of radiant heat and flying debris from an adjacent fire shall be designed and provided in accordance with Tariff Advisory Committee (TAC) stipulations. The partitions meant to reduce the noise level of the transformers, shall have the same fire resistance if the partitions are also used as fire walls. A minimum of 2 meters clearance shall be provided between the equipments and fire walls. The building walls which act as fire walls shall extend at least 1 m above the roof in order to protect it. These walls should be 1-2 hr. fire rated construction.

10.4 Cable and Pipe Trenches

The layout and size of cable and pipe trenches shall be detailed in the GELO. The top of trenches shall be kept at least 25 mm above the gravel level so that rain water does not enter the trench.

(i) Outdoor Cable Trenches: RCC cable trenches shall be constructed in the switchyard and fibre glass/pre-cast RCC removable covers with lifting arrangement, edge protected with suitable galvanized angle iron designed to withstand self weight of top slab in addition to concentrated load of 150 kg at center of span on

each panel.

(ii) Indoor Cable Trenches: RCC indoor cable trenches shall be provided with 50X50X6 mm GI angles grouted on the top edge of the trench wall for holding minimum 7 mm thick mild steel checkered plate covers with lifting arrangement. ISMC GI channels of 75x40 mm shall also be grouted at distances of 600 mm across the indoor cable trenches to support the checkered plates. The width of trench wall should be minimum 200mm

(iii) Trench Drainage: The trench bed shall have a slope of 1/500 along the run and 1/200 perpendicular to the run. In case straight length exceeds 30 m, suitable expansion joint shall be provided at appropriate distances. The expansion joint shall run through vertical wall and base of trench. All expansion joints shall be provided with approved quality PVC water stops of approx. 230x5 mm size. Man holes shall be provided at interval of not more than 30 meters

(iv) Trench - Road Crossings

Suitable box culvert (Single span or multi spans) shall be provided for any road crossing. The box culvert shall extend 1.5 m on each side of road and shall have 230-mm wide, 500 mm high brick parapet wall at ends. If required, the bed of trench on both sides of culvert shall have to be lowered in slope, in 1.5 m length to meet the bed of culvert.

10.5 Foundations For RCC Construction Works

All the foundations except walls of switch house cum administrative and fire hydrant building shall be of Reinforced Cement Concrete. All properties of concrete regarding its strength under compression, tension, shear, punching and bond strength etc. as well as workmanship shall conform to IS: 456. Foundation may be of pad or trapezoidal isolated type.

10.5.1. Sliding and Overturning Stability: All sub-structures shall be checked for sliding and overturning stability both during construction and operating conditions for various combinations of loads. Factor of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the specifications.

10.5.2 Depth of Foundations: In case of overlapping of foundations in switchyard area, deeper foundation shall be constructed first. For the foundations resting on filled up soil, the fill material under foundation / trenches shall be such that the maximum pressure from the footing transferred through fill material will not

exceed the allowable soil bearing pressure of original undistributed soil. In case earth filling is involved due to high fixation of formation level, All foundations shall rest below virgin ground level and the minimum depth excluding lean concrete of all foundations below virgin ground level shall not be less than 500 mm.

10.5.3 Height of Foundations: The Switch Yard foundations shall be at least 100 mm above the finished ground level or as per the manufacturers' design.

10.5.4 Plinth Levels: The plinth level of the Control Room-cum-Administrative building shall be minimum 500 mm above the finished ground level.

10.6 Buildings

10.6.1. Design Criterion: The buildings shall be designed to withstand the earth quake pressure as per the requirements of the National Building Code of India.

10.6.2. Design Loads: Building structures shall be designed for the most critical combinations of dead loads, superimposed loads, equipment loads, crane loads, wind loads, seismic loads, short circuit loads and temperature loads as indicated in IS456 and IS1893. In addition, loads and forces developed due to differential settlement shall also be considered.

10.6.3. DG Building Cum Fire Fighting Pump House and RCC Water Storage Tank: The DG and Fire fighting buildings designed to accommodate up to [two (2)] DG sets, motors / pumps as per fire fighting requirement and a permanent crane, hoist and service trucks mounted on suitable steel structure (I-section / RS joist) below the ceiling for servicing, lifting and maintenance of the heavy equipment shall be constructed adjacent to each other for convenience of maintenance of equipment.

10.6.4. Painting and Finishing: All paints and allied materials shall be of superior quality, conform to the relevant Indian Standards and of approved brands and shades.

10.7 Flooring

The flooring of Control Room-cum-Administrative building except conference room, control room, reception hall and reception stairs shall be made of ordinary polish Kota of approved quality minimum 25 mm thick in plain or diamond pattern.

Entire area around the Control Room-cum-Administrative building, DG-cum-fire fighting building, security hut and the driver's room shall be provided with PCC paving up to 1 meter from the outer edge of the buildings.

10.8 Doors / Windows

Aluminium frames / doors / windows / ventilators (single and double leaf) consisting frame work including vertical styles, top rails, lock (middle) rails and bottom rails with metal fastener and screws shall be fitted with nuts and bolts or using plastic plugs and screws. The Aluminum section to be used shall be of minimum 3 mm, anodized (15 micron) of reputed makes conforming to relevant standards. The Aluminium doors and windows shall be fitted with minimum 5.5 mm thick glass of reputed make with high-class rubber gaskets. The door, floor springs, locks, handles, tower bolts, stoppers with rubber cushion, screws etc. shall be of 1st quality bearing ISI quality certification mark.

10.9 Switchyard Fencing and Gates

Fencing and Gates shall be provided for Switchyard area as per General Electrical Layout Plan. The height of fence post shall be at least 3050 mm.

10.10 Boundary and Retaining Walls

A Boundary wall shall be constructed all around the entire substation in accordance with Good Industry Practice.

10.11 Indian Standards

Civil Works shall comply in all respects to the following codes of the Bureau of Indian Standards (BIS):

IS 110	Ready mixed paint, brushing, grey filler, for enamels for use over primers (second revision)
IS 269	Ordinary Portland Cement, 33 Grade- Specification (fifth revision)
IS 280	Mild steel wire for general engineering purposes (fourth revision with amendment no. 1)
IS 287	Permissible moisture content of timber used for different purposes- Recommendations (third revision)
IS 337	Specification for varnish, finishing, interior
IS 348	Specification for French polis (first revision)

IS 383	Specification for coarse and fine aggregates from natural sources for concrete (second revision)
IS 412	Specification for expanded metal steel sheets for general purposes (second revision)
IS 419	Specification for putty, for use on window frames (first revision)
IS 428	Washable distemper- Specification
IS 456	Plain and Reinforced Concrete - Code of Practice (third revision with amendment no. 4)
IS 702	Specification for industrial bitumen (second revision)
IS 710	Marine plywood- Specification (second revision)
IS 712	Specification for building limes (third revision with amendment no. 1)
IS 733	Specification for wrought aluminium and aluminium alloys, bars, rods and sections for general engineering purposes (third revision)
IS 777	Specification for glazed earthenware tiles
IS 1003 (Part 1)	Timber panelled and glazed shutters - Specification, Part 1: Door shutters (fourth revision)
IS 1003 (Part 2)	Timber panelled and glazed shutters - Specification, Part 2: Window and ventilator shutter (third revision)
IS 1038	Specification for steel doors, windows and ventilators (third revision with amendment no. 3)
IS 1077	Common burnt clay building bricks - Specification (fifth revision)
IS 1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators (with amendment no. 1)
IS 1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones (first revision)

IS 1237	Cement concrete flooring tiles- Specification (second revision)
IS 1322	Bitumen felts for water-proofing and damp-proofing- Specification (fourth revision)
IS 1346	Code of practice for water-proofing of roofs with bitumen felts (third revision)
IS 1361	Specification for steel windows for industrial buildings (first revision)
IS 1397	Kraft paper- Specification (second revision)
IS 1443	Code of practice for laying and finishing of cement concrete flooring tiles (first revision)
IS 1477 (Part 1)	Code of practice for painting of ferrous metals in buildings, Part 1: Pretreatment (first revision)
IS 1477 (Part 2)	Code of practice for painting of ferrous metals in buildings, Part 2: Painting (first revision)
IS 1542	Sand for plaster - Specification (second revision)
IS 1580	Bituminous compounds for water-proofing and caulking purposes- Specification (second revision)
IS 1597 (Part 1)	Construction of stone masonry - Code of practice, Part 1: Rubble stone masonry
IS 1659	Block boards - Specification (fourth revision)
IS 1661	Code of practice for application of cement and cement-lime plaster finishes (first revision)
IS 1834	Specification for hot applied sealing compound for joints in concrete (first revision)
IS 1838	Specification for preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type), Part 1: Bitumen impregnated fibre (first revision with amendment no. 1)
IS 1893	Criteria for earthquake resistant design of structures (fourth

	revision with amendment no. 1)
IS 1948	Specification for aluminium doors, windows and ventilators (with amendment no. 1)
IS 1949	Specification for aluminium windows for industrial buildings (with amendment no. 1)
IS 2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming (second revision)
IS 2114	Code of practice for laying in-situ terrazzo floor finish
IS 2116	Specification for sand for masonry mortars
IS 2185 (Part 1)	Specification for concrete masonry units, Part 1: Hollow and solid concrete blocks
IS 2185 (Part 2)	Specification for concrete masonry units, Part 2: Hollow and solid light weight concrete blocks
IS 2185 (Part 3)	Specification for concrete masonry units, Part 3: Autoclaved cellular aerated concrete blocks
IS 2202 (Part 1)	Wooden flush door shutters(Solid core type) - Specification, Part 1: Plywood face panels
IS 2202 (Part 2)	Wooden flush door shutters(Solid core type) - Specification, Part 2: Particle board and hardboard face panels
IS 2212	Brick works - Code of practice (first revision)
IS 2250	Code of practice for preparation and use of masonry mortars (first revision)
IS 2338 (Part 1)	Code of practice for finishing of wood and wood based materials, Part 1: Operations and workmanship
IS 2338 (Part 2)	Code of practice for finishing of wood and wood based materials, Part 1: Schedules
IS 2339	Aluminium paint for general purposes, in dual container (with amendment no. 1)
IS 2395	Code of practice for painting concrete, masonry and plaster

(Part 1)	surfaces, Part 1: Operations and workmanship
IS 2395 (Part 2)	Code of practice for painting concrete, masonry and plaster surfaces, Part 1: Schedules
IS 2402	Code of practice for external rendered finishes
IS 2571	Code of practice for laying in-situ cement concrete flooring (first revision)
IS 2572	Code of practice for construction of hollow concrete block masonry (first revision)
IS 2645	Specification of integral cement waterproofing compounds
IS 2690 (Part 1)	Burnt clay flat terracing tiles - Specification, Part 1: Machine made (second revision)
IS 2691	Specification for burnt clay facing bricks (second revision)
IS 2750	Specification for steel scaffoldings (with amendment no. 1&2)
IS 2835	Flat transparent sheet glass (third revision)
IS 2932	Specification for enamel, synthetic, exterior: (a) Undercoating, (b) finishing
IS 3036	Laying lime concrete for a waterproofed roof finish - Code of practice (second revision)
IS 3067	Code of practice of general design details and preparatory work for damp-proofing and water-proofing of buildings (first revision)
IS 3068	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete (second revision)
IS 3384	Specification for bitumen primer for use in waterproofing and damp-proofing (first revision)
IS 3461	Specification for PVC asbestos floor tiles
IS 3462	Specification for unbacked flexible PVC flooring (second revision)
IS 3495 (Part1)	Methods of tests for burnt clay building bricks, Part 1: Determination of compressive strength (third revision)

IS 3495 (Part2)	Methods of tests for burnt clay building bricks, Part 2: Determination of water absorption (third revision)
IS 3495 (Part3)	Methods of tests for burnt clay building bricks, Part 3: Determination of efflorescence (third revision)
IS 3495 (Part4)	Methods of tests for burnt clay building bricks, Part 4: Determination of war page (third revision)
IS 3536	Ready mixed paint, brushing, wood primer- Specification (first revision)
IS 3564	Hydraulically regulated door closers - Specification
IS 3696 (Part1)	Safety code of scaffolds and ladders, Part 1: Scaffolds
IS 3696 (Part2)	Safety code of scaffolds and ladders, Part 1: Ladders
IS 3809	Fire resistance test of structures
IS 4020	Door shutters - Methods of tests (Part 1 to 16).
IS 4021	Timber door, window and ventilator frames - Specification
IS 4351	Steel door frames - Specification
IS 4443	Code of practice for use of resin type chemical resistant mortars
IS 4457	Specification for ceramic unglazed vitreous acid resisting tiles
IS 4631	Code of practice for laying of epoxy resin floor toppings
IS 4832	Specification for chemical resistant mortars, Part 2: Resin Type
IS 4860	Specification for acid - resistant bricks
IS 4948	Welded steel wire fabric for general use - Specification
IS 5318	Code of practice for laying of flexible PVC sheet and tile flooring
IS 5410	Cement paint - Specification (first revision)
IS 15489	Paint, Plastic Emulsion - Specification

IS 5437	Wired and figured glass - Specification
IS 5491	Code of practice for laying for in situ granolithic concrete floor topping
IS 6041	Code of practice for construction of autoclaved cellular concrete block masonry
IS 6042	Code of practice for construction of light-weight concrete block masonry
IS 6248	Specification for metal rolling shutters and rolling grills (first revision)
IS 7193	Glass fibre base bitumen felts - Specification (second revision)
IS 7452	Hot rolled steel sections for doors, windows and ventilators - Specification
IS 8042	White Portland Cement - Specification (second revision)
IS 8543 (Part 1/Sec 1)	Methods of testing plastics Part 1 Characterization of polymer structure and size, Section 1 Determination of molecular mass from viscosity
IS 8543 (Part 13/Sec 1)	Methods of Testing Plastics: Part 13 Test for Specific Products - Sec 1 : Buttons (Thermosetting)
IS 13360 (Part 2/Sec 1)	Plastics - Methods of test Part 2 Sampling and preparation of test specimens Sec 1 Compression moulding test specimens of thermoplastics materials
IS 13360 (Part 2/Sec 2)	Plastics - Methods of Testing - Part 2 : Sampling and Preparation of Test Specimens - Section 2 : Compression Moulding of Test Specimens of Thermosetting Materials
IS 13360 (Part 2/Sec 3)	Plastics - Methods of Testing - Part 2 : Sampling and Preparation of Test Specimens - Section 3 : Injection Moulding of Test Specimens of Thermoplastic Materials - General Principles
IS 13360 (Part 3/Sec	Plastics - Methods of Testing - Part 3 : Physical and Dimensional Properties - Section 1 : Determination of Density and Relative

1)	Density of Non-Cellular Plastics
IS 13360 (Part 5/Sec 2)	Plastics - Methods of Testing Part 5 : Mechanical Properties Sec 2 Determination of Tensile Properties - Test Conditions for Moulding and Extrusion Plastics
IS 13360 (Part 5/Sec 3)	Plastics - Methods of testing : Part 5 Mechanical Properties , Section 3 Determination of tensile properties - Test conditions for films and sheets
IS 9197	Specification for epoxy resin, hardeners and epoxy resin compositions for floor topping
IS 9862	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting

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