SECTION-VIII

TECHNICAL SPECIFICATIONS

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CONTENTS

Clause No.	Description	Page No.
1.0	Technical Description of Composite Long Rod Insulators	1
2.0	Equipment Marking	6
3.0	Bid Drawings	6
4.0	Tests and Standards	7
5.0	Annexure-A	16
	Annexure-B	23

TECHNICAL SPECIFICATIONS

SECTION-VIII

1.0 Technical Description of Composite Long Rod Insulators

1.1 Details of Composite Long Rod Insulators

1.1.1 The insulators of the strings shall consist of composite long rod insulators for transmission system application in a very heavily polluted environment. Couplings shall be ball and socket type.

1.1.2 Bidder shall quote such composite insulators which have proven use under foggy/ humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in IEC:62730 (2012).

1.1.3 Insulators shall have sheds of the "open aerodynamic profile without any under ribs" with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

1.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string alongwith hardware fittings shall be as per the standard technical particulars enclosed at Annexure-B.

1.1.5 Dimensional Tolerance of Composite Insulators

The tolerances on all dimensions e.g. diameter, length shall be allowed as follows:

± (0.04d+1.5) mm when d≤300 mm.

± (0.025d+6) mm when d>300 mm **with a maximum tolerance of ± 50 mm**

Where, d being the dimensions in millimeters for diameter, length as the case may be.

The tolerance in creepage distance shall be based on design dimensions and their tolerances. However, no negative tolerance shall be applicable to creepage distance specified in clause 1.1.4.

1.2 Interchangeability

The composite long rod insulators inclusive of the ball & socket connection shall be standard design suitable for use with the hardware fittings of any make conforming to relevant IEC standards.

1.3 Corona and RI Performance

All surfaces shall be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The insulator and metal parts shall be so designed and manufactured that it shall avoid local corona formation and shall not generate any radio interference beyond specified limit under the operating conditions.

1.4 Maintenance

1.4.1 The long rod insulators offered shall be suitable for employment of hot line maintenance technique so that usual hot line operation can be carried out with ease, speed and safety.

1.4.2 All insulators shall be designed to facilitate cleaning and insulators shall have the minimum practical number of sheds and grooves. All grooves shall be so proportioned that any dust deposit can be removed without difficulty either by wiping with a cloth or by remote washing under live line condition.

1.5 Materials

1.5.1 Core

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free, glass and shall exhibit both high electrical integrity and high resistance to acid corrosion.

1.5.2 Housing & Weather sheds

The FRP rod shall be covered by a sheath of HTV silicone rubber compound of a thickness of minimum 5 mm for +/-320kV & above HVDC applications and minimum 3 mm for other voltage levels and AC applications. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. In case any anti-fungal and avian replant admixtures/ additives are added by the manufacturer in the material, the details shall be included by the manufacturers in their MQP. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique to be followed with detailed procedure and sampling shall be furnished by the Supplier and finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile. The weather sheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection molding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection molding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection molding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to

IEC60587**.** The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.5.3 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of forged steel or cast steel; however for socket ends malleable cast iron spheroidal graphite may also be used. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The end fitting shall either be over-moulded or shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.5.4 Grading Rings

Grading rings shall be used for each composite insulator unit as per Standard Technical particulars enclosed at Annexure-B for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. Covered grading rings (having minimum 2 mm sheet thickness of the cover) shall be provided on suspension insulator strings at cross-arm/ cold end as per Standard Technical particulars enclosed at Annexure-B and drawing attached in the relevant section of Technical specification to reduce deposition of bird excreta on polymer insulator sheds. The covered grading ring shall have sloping surface so as to facilitate natural cleaning/ removal of any deposition on its surface. The open type grading ring shall essentially be a round extruded Aluminium Alloy tube of minimum 50 mm diameter, minimum wall thickness of 2.5 mm. The fixing arms of the grading ring shall consist of a holder & a keeper. While the holder shall be either welded or riveted on the corona ring, the keeper shall be bolted onto the holder. To avoid possibility of loosening/ opening of grading ring during service, suitable additional locking measures viz. Lock nut/ bolt patch/ locking washer etc. shall be provided by the supplier. Gap between holder & keeper shall be kept uniformly as 32mm for up to 120kN and 36mm for 160kN & 210kN.

The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/ corona cutting/ exceeding of permissible electrical stress of material. Also for ensuring correct installation of grading rings, a proper slot shall be provided at the outside edge of the End fittings and on grading ring holders. The design of the grading rings shall be such that it will only fit in the designated slot facing correct installation direction. The position of the slots shall be at suitable distance on end fittings to ensure acceptable levels of radio and TV noise and voltage gradient on and within the insulator.

The insulator supplier shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona. The electric field for dry uncontaminated polymer insulators shall not be more than following critical values

I. Internal to the fiberglass rod & rubber weather shed material: 30 kV/cm (rms).
II. Surface E-field magnitudes on weather shed material: 4.5 kV/cm (rms) measured 0.5 mm above the surface of the sheath.
III. Surface E-field magnitudes on end-fittings & corona rings: 21 kV/cm (rms)

Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The design & supply of grading rings shall be in the scope of the composite insulator supplier.

Supplier shall supply extra 10% quantities of grading rings as O&M spares at no extra cost to the Purchaser.

1.5.5 Bolts and nuts for grading rings shall be galvanized as per IS 1367 (Part 13)/ IS 2629. Fully threaded bolts confirming to relevant Indian Standard shall be used. Dimensions of bolts/nuts shall be M10x50mm. Bolts shall be of minimum 4.6 grade. In case bolts & nuts of other materials viz. stainless steel, aluminium alloy, etc. are proposed to be used by the supplier, these shall conform to relevant Indian/International standards and complete details shall be submitted by the supplier for review & approval by the Employer.

1.5.6 **The details of materials for different component are listed as in Table-I**

TABLE-1 : (Details of Materials)

S. No.	Item	Material treatment	Reference Material Grade
1.	Ball End	Forged Steel	Forged Steel, Class 4 as per IS 2004
			Forged Steel, EN8D as per BS970
			41Cr4 as per ISO 683-18-1996 or EN10083-3-2006
		Cast Steel	C40 as per EN-10083-2
			C45 as per EN-10083-2
2.	Socket End	Forged Steel	Forged Steel, Class 4 as per IS 2004
			Forged Steel, EN8D as per BS970
			41Cr4 as per ISO 683-18-1996 or EN10083-3-2006
		Cast Steel	C40 as per EN-10083-2
			C45 as per EN-10083-2
		Spheroidal Graphite Cast Iron	SGCI-450/10 as per IS 1865:1991
3.	Ring	Covered type : Aluminium Casting	LM6 as per BS 1490/ 4600 as per IS 617
		Open type: Aluminium Extrusion	High Strength Al. Alloy, 63400 as per IS 733, 63401 as per IS 5082, 6063 or 6061 as per EN 573
4.	Holder/ Keeper	Mild Steel	E410 as per IS-2062
		Cast Steel	C45, EN-10083-2
			65-35 as per ASTM A27
			A 1020 ASTM A732

		Aluminium Extrusion	High Strength Al. Alloy, 63400 as per IS 733, 63401 as per IS 5082, 6063 or 6061 as per EN 573
		Aluminium Casting (for holder only)	LM6 as per BS 1490/ 4600 as per IS 617 (min. 8 mm thickness)
5.	Silicone Rubber	High Temperature Vulcanised (HTV) Silicone Rubber	

1.6 Workmanship

1.6.1 All the materials shall be of latest design and conform to the best modern practices adopted in the extra high voltage field. Bidders shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for transmission lines specified and will give continued good service.

1.6.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.

1.6.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

1.6.4 The core shall be sound and free of cracks, impurities and voids that may adversely affect the insulators.

1.6.5 Weather sheds/ Housing shall be uniform in quality. It shall be free from voids and impurities. Weather sheds/ Housing shall be clean, sound, smooth and free from gross defects and excessive flashing at parting lines.

1.6.6 End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

1.6.7 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/sq.m. and shall be in accordance with the requirement of ISO:1461 (E) and shall satisfy the tests mentioned in ISO:1460 (E).

However, under marine/extreme environment/coastal areas, as specifically mentioned in BPS, the end fittings shall have a minimum average coating of zinc equivalent of 790 gms / sq m (equivalent to 110 microns) of surface area and the steel holder/ keeper shall have a minimum overall zinc coating of 900 gms / sq m of surface area. Also, in such case, stainless steel bolts/ nuts shall only be used.

Spring washers shall be electro-galvanised. Stainless steel washer may be used as an alternative.

The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive

dips each lasting for one (1) minute duration under the standard preece test. However, fasteners shall withstand four dips while spring washers shall withstand three dips under the standard preece test. The galvanizing shall be carried out only after any machining.

1.6.8 The supplier shall guarantee that there shall not be any failure/ decapping / breaking of insulators on line under normal operating condition. In the event of any failure/ decapping /breaking of insulators during the first ten years of service, Supplier shall supply to the Purchaser free of cost spare insulators equal to 10 times the failed insulator quantity. Further, in case of decapping / Breaking and subsequent line drop, during the first ten years of service, the supplier shall also have to pay Rs 1,00,000/- (Rs one lakh only) per dropped string towards expenditure to be incurred by POWERGRID for this line repair.

2.0 **Equipment Marking**

2.1 Each composite long rod unit shall be legibly and indelibly marked with the trade mark of the manufacturer, name of POWERGRID and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word 'kN' to facilitate easy identification and to ensure proper use. Holder of grading rings shall be legibly and indelibly marked with trade mark of the composite insulator supplier.

2.2 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap/end fitting of each composite long rod of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For 70 kN long rod unit	:	Black
For 90 kN long rod unit	:	Red
For 120 kN long rod unit	:	Yellow
For 160 kN long rod unit	:	Green
For 210kN long rod unit	:	Blue

3.0 **Bid Drawings**

3.1 The Bidder shall furnish full description and illustration of the material offered.

3.2 The Bidder shall furnish along with the bid the outline drawing of each insulator unit along with grading rings including a cross sectional view of the long rod insulator unit. The drawing shall include but not limited to the following information:

(a) Major Dimensions with manufacturing tolerances

(b) Number of sheds

(c) Minimum Creepage distance with positive tolerance

(d) Protected creepage distance

(e) Unit mechanical and electrical characteristics

(f) Size and weight of ball and socket parts

(g) Weight of composite long rod units

(h) Materials

3.3 After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Purchaser for approval. After getting approval from Purchaser, the Supplier shall submit 10 more copies of the same drawing along with a soft copy to the Purchaser for further distribution and field use at Purchaser's end.

3.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

4.0 Tests and Standards

4.1 Type Tests

The required type tests on composite longrod units, components, materials and complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

i. Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and

ii. Tests have been conducted not prior to 5 (five) years from the date of bid opening.

In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

4.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings:

Sl. No.	Tests	Ref	Strings on which test to be conducted*.
a)	Power frequency / DC voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	IEC: 383-1993/ IEC:60-1	All strings

b)	Switching surge voltage withstand test under wet condition (applicable for 400kV & above voltage level)	IEC:383-1993	All strings
c)	Impulse voltage withstand test under dry condition	IEC:383-1993	All strings
d)	Corona (AC / DC) and RIV test under dry condition (applicable for 400kV & above voltage level)	Annex-A	All strings
e)	Mechanical Strength test	As per Annex-A/ B	All strings
f)	Vibration test	As per Annex-A/ B	All strings except Pilot*
g)	AC Salt-fog pollution withstand test / DC Pollution withstand test	Annex-A	All strings except Pilot*

**Tests indicated at f) & g) shall not be required to be carried out on DIS & DT strings of 132 & 220kV TL and Single Tension strings of 400kV & 765 kV TL*

These type tests on the insulator string assembly shall not be required to be repeated due to use of specified size of grading rings even in case valid type test reports for the offered composite longrod insulator strings are available with different size of grading rings.

4.1.2 On Composite Insulator Units

(a)	Tests on interfaces and connections of metal fittings	IEC: 61109-2008
(b)	Assembled core load time test	IEC: 61109-2008
(c)	Damage limit proof test and test of tightness of interface between end fittings and insulator housing.	IEC: 61109-2008
(d)	High Pressure washing test	Annexure-A
(e)	Brittle fracture resistance test	Annexure-A
(f)	Dye penetration test	IEC: 61109-2008 & IEC 62217-2012
(g)	Water diffusion test	IEC: 61109-2008
(h)	Tracking and erosion test	IEC: 61109-2008
(i)	Hardness test	IEC: 61109-2008
(j)	Accelerated weathering test	IEC: 61109-2008
(k)	Flammability test	IEC: 61109-2008
(l)	Silicone content test	Annexure-A
(m)	Recovery of Hydrophobicity test	Annexure-A
(n)	Torsion test	Annexure-A

Hardness test, Accelerated weathering test **&** Flammability test, specified under Clause No.4.1.2 above shall be conducted on housing/ weather shed of anyone rating of composite long rod Insulator for the same type of material.

4.2 **Acceptance Tests:**

4.2.1 For Composite Long Rod Insulators

a)	Verification of dimensions	IEC : 61109**-**2008
b)	Galvanising test	IEC : 60383
c)	Verification of end fittings	IEC: 61109 -2008
d)	Recovery of Hydrophobicity	Annexure-A
e)	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC : 61109-2008
f)	Tests on interfaces and connections of metal fittings	IEC: 61109**-**2008
g)	Silicone content test	Annexure-A
h)	Brittle Fracture Resistance Test	Annexure-A
i)	Dye Penetration Test	IEC :61109-2008
j)	Water Diffusion Test	IEC : 61109-2008

The test 4.2.1.(f) to (j) shall be carried out as acceptance test on any one lot.

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IEC 61109.

4.3 Routine Tests

4.3.1 **For Composite Long Rod Insulator Units**

a)	Visual Examination	As per IEC:61109-2008
b)	Mechanical routine test	As per IEC:61109 -2008

4.4 Tests During Manufacture

On all components as applicable

a)	Chemical analysis of zinc used for galvanizing	As per Annexure-A
b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	As per Annexure-A
c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	As per Annexure-A

d)	Tracking and erosion test on insulating material	IEC 60587

4.5 Testing Expenses

4.5.1 As mentioned under clause 4.1 above, no type test charges shall be payable to the supplier.

4.5.2 For Type Tests which involves the tests on the complete insulator string with hardware fitting, standard hardware fittings similar to existing insulator strings shall be arranged and used by the insulator supplier at his own cost.

4.5.3 In case of failure in any type test the supplier is either required to modify the design of the material & successfully carryout all the type tests as has been detailed out in Clause 4.1 of this specifications or to repeat that particular type test at least three times successfully at his own expenses.

4.5.4 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

4.5.5 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

4.5.6 In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Purchaser's representative shall be deducted from the contract price. Also if on receipt of the Supplier's notice of testing, the Purchaser's representative does not find the material or test setup / equipments to be ready for testing, the expenses incurred by the Purchaser for re-deputation shall be deducted from contract price.

4.5.7 The Supplier shall intimate the Purchaser about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of testing in India) and at least 6 weeks advance (in case of testing abroad) of the scheduled date of testing during which the Purchaser will arrange to depute his representative to be present at the time of carrying out the tests.

4.6 Sample Batch for Type Testing

4.6.1 The Supplier shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Purchaser. The Supplier shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Purchaser.

4.6.2 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Purchaser's representative.

4.7 Schedule of Testing

4.7.1 The Bidder has to indicate the schedule of following activities in their bids :

a) Submission of drawing for approval.

b) Submission of Quality Assurance Programme for approval.

c) Offering of material for sample selection for type tests.

d) Type testing.

4.8 Additional Tests

4.8.1 The Purchaser reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the Specifications.

4.8.2 The Purchaser also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test center. In case of evidence of non-compliance, it shall be binding on the part of the Supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Purchaser.

4.9 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators.

4.10 Test Reports

4.10.1 Copies of type test reports shall be furnished in at least six (6) copies alongwith one original. One copy shall be returned duly certified by the Purchaser only after which the commercial production of the concerned material shall start.

4.10.2 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Purchaser, only after which the material shall be dispatched.

4.10.3 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Purchaser’s representative.

4.10.4 Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Purchaser.

4.11 **Inspection**

4.11.1 The Purchaser’s representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier’s and sub-Supplier’s works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

4.11.2 The material for final inspection shall be offered by the Supplier only under packed condition as detailed in clause No.4.12 of the specification. The Purchaser shall select samples at random from the packed lot for carrying out acceptance tests. The lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

4.11.3 The Supplier shall keep the Purchaser informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

4.11.4 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Purchaser in writing. In the latter case also the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

4.11.5 The acceptance of any quantity of material shall be no way relieve the Supplier of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such material are later found to be defective.

4.12 Packing and Marking

4.12.1 All insulators shall be packed in suitable PVC/ plastic tubes of atleast 3 mm thickness or water resistant packing material and the packaging shall not break during storage & transportation even in overhang condition during transportation. Further, last 20% quantity of insulators shall be packed in PVC/ plastic tubes only to ensure long storage of about 5 years. The packing shall provide protection against rodent. The Supplier shall furnish detailed design of the packing. For marine transportation, crates shall be palleted.

4.12.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

4.12.3 Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

4.12.4 All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each case/crate shall have all the markings stenciled on it in indelible ink.

4.12.5 The Supplier shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation due to improper packing.

4.12.6 #To prevent birds from pecking the insulators installed on transmission lines before charging, removable plastic/polyethylene/polypropylene covers for 10% of the insulators of each rating shall be supplied by the manufacturer. These covers should have provisions/attachments for easy removal from the installed insulators and is in addition to the normal packing provided by the manufacturer.

(# Clause 4.12.6, not applicable for insulator replacement/ AM packages)

4.13 **Standards**

The insulator strings and its components shall conform to the following Indian/International Standards which shall mean latest revision, with amendments/
changes adopted and published, unless specifically stated otherwise in the Specification.

4.13.1 In the event of supply of insulators conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent or better to those specified. In case of award, salient features of comparison between the standards proposed by the Bidder and those specified in this document will be provided by the Supplier to establish equivalence.

Sl. No.	Indian Standard	Title	International Standard
1.	IS:209-1992	Specification for zinc	BS:3436
2.	IS:406-1991	Method of Chemical Analysis of Slab Zinc	BS:3436
3.	IS:731-1991	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	BS:137- (I&II) IEC:60383
4.	IS:2071 Part (I) – 1993 (Part(II)-1991 Part(III)-1991	Methods of High Voltage Testing	IEC:60060-1
5.	IS:2486 Part- I-1993 Part- II-1989 Part-III-1991	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	BS:3288 IEC:60120 IEC:60372
6.	IS:2629-1990	Recommended Practice for Hot, Dip Galvanisation for iron and steel	ISO-1461 (E)
7.	IS:2633-1992	Testing of Uniformity of Coating of zinc coated articles	
8.	IS:6745-1990	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	BS:433-1969 ISO:1460-1973
9.	IS:8263-1990	Methods of RI Test of HV insulators	IEC:60437 NEMA Publication No.07/ 1964/ CISPR
10.	IS:8269-1990	Methods for Switching Impulse test on HV insulators	IEC:60506
11.		Thermal Mechanical Performance test and mechanical performance test on	IEC: 60575

Sl. No.	Indian Standard	Title	International Standard
		string insulator units	
12.		Salt Fog Pollution Voltage Withstand Test	IEC:60507
13.		Composite insulators for A.C. Overhead lines with nominal voltage greater than 1000V – Definitions, test methods and acceptance criteria	IEC 61109
14.		Selection and dimensioning of high voltage insulators intended for use in polluted conditions: Polymer Insulators for AC systems	IEC:60815-**3**
15.		Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V	IEC:60383
16.		Composite string insulator units for overhead lines with a nominal voltage above 1000V : Standard strength classes and end fittings	IEC 61466-1
17.		Composite string insulator units for overhead lines with a nominal voltage above 1000V : Dimensional and electrical characteristics	IEC 61466-2
18		Electrical Insulating materials used under severe ambient conditions –Test methods for evaluating resistance to tracking and erosion	IEC 60587
19		Polymeric insulators for indoor and outdoor use with nominal voltage greater than 1000V- General definitions, tests, methods and acceptance criteria.	IEC 62217
20	IS 16784: 2018	Insulators for Overhead Lines — Composite Suspension and Tension Insulators for a.c. Systems with a Nominal Voltage Greater Than 1 000 V — Definitions, Test Methods and Acceptance Criteria	

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution

	101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva, SWITZERLAND
BIS/IS	Beureau Of Indian Standards. ManakBhavan, 9, Bahadur Shah ZafarMarg, New Delhi - 110001.INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

1.0 Tests on Complete Strings with Hardware Fittings

1.1 Corona Extinction Voltage Test (Dry)

The sample assembly consisting of complete insulator string when subjected to power frequency/ DC voltage shall have a corona extinction voltage of not less than the requirement stipulated in the table below:-

Voltage Level	Maximum Height of the conductor above ground (m)	Min. Corona extinction voltage (kV)
400 kV	8.84	320 (305 for RIV test)
765 kV	15	510
+/-500kV HVDC	Such that voltage gradient is not less than 22kV/cm	550
+/-800kV HVDC	Such that voltage gradient is not less than 22kV/cm	880

There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 60383.

1.2 RIV Test (Dry)

Under the conditions as specified under (1.1) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz. The test procedure shall be in accordance with IS: 8263/ IEC: 60437.

1.3 Mechanical Strength Test

1.3.1 Mechanical Strength Test for insulator strings.

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/ dead end assembly shall be loaded to reproduce design conditions. The testing programme varies with string and tower types according to following table:

String Type	Total Test Load* (kN)	Direction** of Load	Duration of Load (Min.)	Sequence of Testing ***
132kV (SINGLE PANTHER)				
Double I Suspension	94	1	5	1
	140	1	1	2
	F****	1	-	3
Single I Suspension	47	1	5	1
	70	1	1	2
	F****	1	-	3

Single Tension	60	1	5	1
	90	1	1	2
	F****	1	-	3
Double Tension	120	1	5	1
	180	1	1	2
	F****	1	-	3
220 kV (SINGLE ZEBRA)				
Double I Suspension	94	1	5	1
	140	1	1	2
	F****	1	-	3
Single I Suspension	47	1	5	1
	70	1	1	2
	F****	1	-	3
Single I Suspension Pilot	47	1	5	1
	70	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension	160	1	5	1
	240	1	1	2
	F****	1	-	3
400kV (TWIN MOOSE)				
Single V	80	2	5	1
	60	1	5	2
	90	1	1	3
	F****	1	_	4
Single I Suspension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single I Suspension Pilot	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension	214	1	5	1
	320	1	1	2
	F****	1	-	3
400kV (TRIPLE SNOWBIRD)				
Double I Suspension	161	1	5	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot	80	1	5	1
	120	1	1	2
	F****	1	-	3

Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension	281	1	5	1
	420	1	1	2
	F****	1	-	3
400kV (QUAD MOOSE)				
Double I Suspension	161	1	5	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Quad Tension	429	1	5	1
	640	1	1	2
	F****	1	-	3
+/-500kV HVDC (QUAD BERSIMIS)				
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	-	5
Quadruple Tension (160 kN)	429	1	5	1
	640	1	1	2
	F****	1	-	3
+/-500kV HVDC (QUAD LAPWING)				
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	-	5
Quadruple Tension (210 kN)	560	1	5	1
	840	1	1	2
	F****	1	-	3
765kV S/C (QUAD BERSIMIS)				
Double I	160	1	5	1
	240	1	1	2
	F****	1	1	3
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3

	210 F****	3 3	1 _	4 5
Double V	280 260 260 420 F****	2 3 4 3 3	5 5 5 1 _	1 2 3 4 5
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Quadruple Tension	540 840 F****	1 1 1	5 1 _	1 2 3
Single I & V Pilot	80 120 F****	1 1 1	5 1 _	1 2 3
765kV D/C (HEXA ZEBRA)				
Double I Suspension	214 320 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	107 160 F****	1 1 1	5 1 -	1 2 3
Single Tension	107 160 F****	1 1 1	5 1 -	1 2 3
Quad Tension	560 840 F****	1 1 1	5 1 -	1 2 3

` Notes:

* : The total test must be established gradually at a steady rate.

**: Direction of load

1. following string axis
2. following bisector of string angle.
3. Following with respect to vertical, half the string angle, along the axis of one of the arm of the Vstring
4. Following with respect to vertical, half the string angle +15 deg, along the axis of one of the arm of the Vstring

*** : The insulator string must be completely unloaded and examined, then the proper direction of loading established before proceeding to the next sequential test.

****: F denotes Failure load

The insulator string shall be deemed acceptable if, for all tests loads except failure load, the string components do not show any visual signs of deformation or fracture, and the same components may be disassembled by hand, except for removal of cotter pins and initial loosening of the nuts. The failure load shall be recorded and must be greater than all previous tests loads.

1.4 **Vibration Test**

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspension string, a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and the each sub-conductors tensioned at 25% of conductor UTS shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductors throughout the duration of the test. Vibration dampers shall not be used on the test span. All the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than $1000/f^{1.8}$ where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test, the insulators shall be examined for looseness of pins and cap or any crack. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the Mechanical performance test as per relevant standards.

1.5 AC Salt-fog pollution withstand test

This test shall be carried out in accordance with IEC:60507. The salinity level for composite long rod insulators shall be 160Kg/m3 NACL.

1.6 DC pollution withstand test

This test shall be carried out as per IEC-61245 with solid layer method. The D.C. pollution withstand voltage (negative) shall be 500kV for +/-500kV HVDC insulators as applicable at average ESDD of 0.1 mg / sq. cm.

2.0 **<u>Composite Longrod Insulator Units</u>**

2.1 **Brittle Fracture Resistance Test**

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO_3 acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm.The rod shall withstand 80% of SML for 96 hours.

2.2 Recovery of Hydrophobicity Test

(1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.

(2) Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1″ x 1″. Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.

(3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.

(4) Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

2.3 Silicone content test

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Purchaser& Supplier in Quality Assurance Programme.

2.4 High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800kPa with nozzles of 6mm diameter at a distance of 3m from nozzles to the insulator. The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be 1 minute wet power frequency withstand test at 275kV r.m.s for 132 KV, 460kV r.m.s for 220 KV, 680 kV r.m.s for 400 KV and 830kV r.m.s for 765 KV Lines and 1 minute DC withstand test at -500 kV DC for ±500 kV HVDC.

2.5 Torsion Test

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55 Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IEC 61109.

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analysed as per IS:209-1979. The purity of zinc shall not be less than 99.95%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Purchaser in Quality Assurance Programme.

3.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic, particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Purchaser in Quality Assurance Programme.

Annexure-B

Standard Technical Particulars of Composite Long Rod Insulators:

				132kV AC		220kV AC		400kV				765kV			±500kV HVDC	
S. No.	**Description**		**Unit**	**70 KN**	**90KN**	**70KN**	**120KN**	**90KN**	**120KN**	**160KN**	**210KN**	**120KN**	**160KN**	**210KN**	**160 kN**	**210 kN**
1.	Size and Designation of Ball & Socket assembly		mm	16 mm (Alt-B)	16 mm (Alt-B)	16 mm (Alt-B)	20 mm	16mm (Alt-B)	20 mm	20 mm	24 mm	20 mm	20 mm	24mm	20 mm	24mm
2.	Core diameter*		mm	20	20	20	20	20	20	24	24	20	24	24	24	24
3.	Nominal length		mm	1450	1450	2030	2175	3335	3335	3910	3910	2900	2975	2975	3485/ 3230	3485
4.	Minimum Creepage distance		mm	4495	4495	7595	7595	13020	13020	13020	13020	12400	12400	12400	13750	13750
5.	No. of grading rings (min.)		Nos.	1	1	1	1	2	2	2	2	2	2	2	2	2
6.	Nominal Diameter of grading ring	Covered ring **	mm	–	–	–	–	300	300	300	300	300	300	300	300	300
		Other rings	mm	200	200	200	200	300	300	300	300	370	370	370	370	370
7.	Depth of grading ring (open type)		mm	105-125	105-125	105-125	105-125	105-125	105-125	140-150	140-150	125-155	125-155	140-155	-	-

Note: **The core dia of composite insulators mentioned at Row No.2 is for indicative purpose. The bidder shall offer composite long rod insulators of suitable core dia, not less than the value specified above, to meet specified E&M and torsion strength requirements.*

*** Covered ring shall be required for Single I/ Double I suspension insulator strings only.*

Standard Technical Particulars of Insulator Strings

1) Standardized Technical Particulars of 132 kV Insulator strings

Sl.	Description	Unit	Standard Technical Particular value			
			Single 'I' suspension string	Double 'I' suspension string	Single Tension string	Double Tension string
1.0	**No. of Insulator Units**	**Nos.**	**1X1**	**2X1**	**1X1**	**2X1**
2.0	pf withstand voltage under wet condition	kV (rms)	275			
3.0	Impulse withstand voltage (dry) Positive					
a)	Negative	kVp	650			
b)		kVp	650			
4.0	Dry Arcing distance	mm	1200			
5.0	Mechanical strength	KN	70	2 X 70	90	2 x 90

2) Standardized Technical Particulars of 220 kV Insulator strings

Sl.	Description	Unit	Standard Technical Particular value				
			Single 'I' suspension string	Single 'I' suspension Pilot string	Double 'I' suspension string	Single Tension string	Double Tension string
1.0	**No. of Insulator Units**	**Nos.**	**1X1**	**1X1**	**2X1**	**1X1**	**2X1**
2.0	pf withstand voltage under wet condition	kV (rms)	460				
3.0	Impulse withstand voltage (dry)						
a)	Positive	kVp	1050				
b)	Negative	kVp	1050				
4.0	Dry Arcing distance	mm	1800				
5.0	Mechanical strength	KN	70	70	2X 70	120	2X120

3) Standardized Technical Particulars of 400 kV D/C (Twin Moose) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular value				
			Single V Suspension	Single 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Double Tension
1.0	**No. of Insulator Units**	**Nos.**	2X1	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680				
3.0	Switching withstand voltage (dry)						
a)	Positive (Peak)	kV	1050				
b)	Negative (Peak)	kV	1050				
4.0	Impulse withstand voltage (dry)						
a)	Positive (Peak)	kV	1550				
b)	Negative (Peak)	kV	1550				
5.0	Dry Arcing distance	mm	3050				
6.0	Mechanical strength	kN	90	120	120	120	2X160

4) Standardized Technical Particulars of 400 kV D/C (Triple Snowbird) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular value			
			Double 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Double Tension
1.0	**No. of Insulator Units**	**Nos.**	2 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV	1050			
b)	Negative (Peak)	kV	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	1550			
b)	Negative (Peak)	kV	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2 X 120	120	120	2X210

5) Standardized Technical Particulars of 400 kV D/C (Quad Moose) Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular value			
			Double 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Quadruple Tension
1.0	**No. of Insulator Units**	**Nos.**	2 x 1	1 x 1	1 x 1	4 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV	1050			
b)	Negative (Peak)	kV	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	1550			
b)	Negative (Peak)	kV	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2X120	120	120	4X160

6) Standardized Technical Particulars of 765 kV S/C Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular value						
			Single 'V' Suspension	Double 'I' Suspension	Double 'V' Suspension	Single 'V' Suspension PILOT	Single 'I' Suspension PILOT	Single Tension	Quadruple Tension
1.0	**No. of Insulator Units**	**Nos.**	2x 2	2x 2	2x 2 x 2	2x 2	1 x 2	1 x 2	4 x 2
2.0	pf withstand voltage under wet condition	kV (rms)	830						

3.0	Switching withstand voltage (dry)								
a)	Positive (Peak)	kV	1550						
b)	Negative (Peak)	kV	1550						
4.0	Impulse withstand voltage (dry)								
a)	Positive (Peak)	kV	2400						
b)	Negative (Peak)	kV	2400						
7.0	Dry Arcing distance	mm	5100						
8.0	Mechanical strength	kN	210 along each limb	240	2 x 210 along each limb	120 along each limb	120	1 x 120	4 x 210

7) Standardized Technical Particulars of 765 kV D/C Insulator strings

Sl. No.	Description	Unit	Standard Technical Particular value			
			Double 'I' Suspension	Single 'I' Suspension PILOT	Single Tension	Quadruple Tension
1.0	**No. of Insulator Units**	**Nos.**	2x 2	1 x 2	1 x 2	4 x 2
2.0	pf withstand voltage under wet condition	kV (rms)	830			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV	1550			
b)	Negative (Peak)	kV	1550			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV	2400			
b)	Negative (Peak)	kV	2400			
5.0	Dry Arcing distance	mm	5100			
6.0	Mechanical strength	kN	2X 160	160	160	4 x 210

8) Standardized Technical Particulars of +/-500kV HVDC Insulator strings

SNo	Description	Unit	Standard Technical Particular value		
			Single 'V' Suspension string	Quad Tension string (Quad Bersimis)	Quad Tension string (Quad Lapwing)
1.0	**No. of Insulator Units**	**Nos.**	**2 X 2**	**4X2**	**4X2**
2.0	DC withstand voltage under wet condition	kV	550 (negative)		
3.0	Impulse withstand voltage (dry)				
	Positive / Negative	kV_P	1800/1800		
4.0	Switching Withstand voltage (dry)				
	Positive / Negative	kV_P	1000/1000		
5.0	Dry Arcing distance	mm	3050		
6.0	Mechanical strength	kN	2 X 210	4X 160	4 X 210