SECTION-VIII

COMPOSITE LONG ROD INSULATOR

TECHNICAL SPECIFICATIONS

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TECHNICAL SPECIFICATIONS

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TECHNICAL SPECIFICATIONS

SECTION-VIII

COMPOSITE LONG ROD INSULATOR

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 satisfactorily. 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 +10 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 Indian 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. Glass Transition Temperature (Tg) for FRP rod to be minimum 140° C.

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. The housing & weather sheds should have silicon content of minimum 32% by weight. The minimum dielectric strength (BDV) of silicon rubber compound shall be 20kV/mm. 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 IEC 60587**.** 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 at each side of the insulators for ±800kV HVDC Insulators (420kN & 160kN) and at line end for metallic return insulators (160 & 210kN) 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 thickness) shall be provided on tower side of vertical portion (II-portion) of 420kN Insulators to be used in “Y-string” & 160kN suspension Pilot insulator strings, of ±800HVDC lines, at cross-arm/ cold end as per the drawing attached at Section-III of Technical specification to reduce deposition of bird excreta on polymer insulator sheds.

For upto 765kV voltage level, 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. For 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. However, Supplier may offer

higher size of grading rings for limiting electric field as per criteria mentioned herein below.

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 with the proposed placement and design of corona. The insulator supplier must provide EFM report with all limits as per criteria mentioned below. Any modifications to achieve the same shall be done in Insulator assembly only.

I. Below details shall be mentioned in the report: -

a. String configuration
b. The EFM analysis must be complied with satisfying all dimensions as per the drawings for the same type of insulator with hardware fittings as a whole.
c. Method and Software used for analysis with license number with images of the same.
d. Assumptions along with insulator dimension including arching distance.
e. Inputs for the software:
   1) Voltage & Relative Permittivity and conductivity of material i.e., for FRP Rod, silicon rubber insulator, Corona rings, ball and socket end fittings.
   2) Voltage applied on live side
   3) Dielectric strength of silicon rubber

II. Criteria:

The electric field for dry uncontaminated polymer insulators shall not be more than the following critical values:

a. The E-field on the end fittings seal should not exceed 3.5 kV/cm (rms)

b. Along the Insulator Sheath, the E-field should not exceed 4.2 kV/cm (rms) over a distance of more than 10mm.
c. Surface E-field magnitudes on end fittings & Corona rings: 18 kV/cm (rms).
d. Internal to the fiberglass rod & rubber weather shed material: 30 kV/cm (rms).

III. The E-field stress analysis should be carried out both for live side and tower side at highest system voltage.

IV. Reports shall include images of E-field stress and its measured values of all the above factors taken from software.

V. The results should be provided in tabular form along with requirements.

VI. All drawings for insulator and hardware fittings used shall be submitted along with reports and supplier shall ensure same drawings shall only be used for on-going projects.

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)

Sl. 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		Forged Steel	Forged Steel, Class 4 as per IS 2004

	Socket End		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
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
		Aluminium Casting	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/sqm. 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 gm /sqm (equivalent to 110 microns) of surface area and the steel holder/ keeper shall have a minimum overall zinc coating of 900 gm/ sqm 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/ de-capping/ breaking of insulators on line under normal operating condition. In the event of any failure/ de-capping/ breaking/ rise in temperature of insulator housing & weather sheds by more than 5 degree w.r.t ambient temperature (suspected insulators) 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/suspected insulator quantity. Further, in case of de-capping/ Breaking and subsequent line drop (i.e detachment of any sub-conductor from hardware fittings) during the first ten years of service, the supplier shall also have to pay Rs 1,00,000/- (Rupees 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
For 320kN long rod unit	:	Pink
For 420 kN long rod unit	:	Purple

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. Type test reports contain validity details of Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/values specified in Technical Specification/relevant standards (IS/ IEC) and compliance to the same and

iii. The Equipment (i.e. Composite Long Rod Insulator) shall be supplied from the same manufacturing works, where from the sample was manufactured and successfully type tested as per relevant standard or at the works of Parent organization in case of technology transfer/ Joint Venture (JV) for the initial period of 03 years from the date of establishment of manufacturing plant.

In case of own manufacturing plant at different location within India, the type test of the original manufacturing works shall also be acceptable for the equipment manufactured and supplied from the different location subject to the following conditions:

a) the relevant standard does not bar the same,
b) the equipment being manufactured at different locations shall be identical in design, drawings, specifications, ratings to that of the type tested sample in the original facility (where it was manufactured and successfully type tested),
c) the equipment being manufactured at different locations shall be identical in material & critical components, manufacturing process/ practices, and quality control to that of the type tested sample in the original facility (where it was manufactured and successfully type tested),
d) Also, while submitting the Type Test Reports, the Original Equipment Manufacturer (OEM), shall furnish an undertaking for above conditions (a), (b) and (c).

iv. The Type test report(s) of the equipment shall not be older than 10 (ten) years as on the originally scheduled last date of bid submission (Soft Copy).

v. While submitting the Type Test Reports, the Original Equipment Manufacturer (OEM), shall furnish an undertaking with it declaring that there is:
   a) No change in the Design
   b) No change in the material,
   c) No change in manufacturing process, and
   d) No amendment/ revision in the relevant standard as regard to type test conditions, since the type test.

Further, test certificates shall also be considered valid, if the same has already been approved/ accepted by POWERGRID & tests have been conducted within the above-mentioned validity period.

In case the tests have been conducted earlier than the above stipulated period or in case of revision/ amendment in the provisions/ test procedure of the IS/IEC as referred in the TS or in the event of any discrepancy in the test report (i.e. due to non-inclusion of validity details of calibration certificate, desired information etc. or any test not applicable due to any design/ material/ manufacturing process 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 that shall be used in the transmission line portion covered under the package
b)	Switching surge voltage withstand test under wet condition (applicable for 400kV & above voltage level)	IEC 383:1993	
c)	Impulse voltage withstand test under dry condition	IEC 383:1993	
d)	Corona (AC/ DC) and RIV test under dry condition (applicable for 400kV & above voltage level)	Annexure-A	
e)	Mechanical Strength test	Annexure-A	
f)	Vibration test	Annexure-A	
g)	AC Salt-fog pollution withstand test/ DC Pollution withstand test	Annexure-A	

Note: Tests indicated at f) & g) shall not be required to be carried out on Pilot strings for all voltage levels, DIS & DT strings of 132 & 220kV (single ZEBRA) TL and Single Tension strings of 220 kV (twin MOOSE), 400kV & 765 kV TL.

Altitude correction factor (For altitude mentioned in Section-1A) as per IEC-60071-2 shall be considered in the specified voltage withstand values for above tests.

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	IS 16784
(b)	Assembled core load time test	IS 16784
(c)	Damage limit proof test and test of tightness of interface between end fittings and insulator housing.	IS 16784
(d)	High Pressure washing test	Annexure-A
(e)	Stress corrosion test	IS 16784
(f)	Dye penetration test	IS 16784 & IEC 62217
(g)	Water diffusion test	IS 16784
(h)	Tracking and erosion test	IS 16784
(i)	Hardness test	IS 16784
(j)	Accelerated weathering test	IS 16784
(k)	Flammability test	IS 16784
(l)	Silicone content test	Annexure-A
(m)	Recovery of Hydrophobicity test & Corona test	Annexure-A
(n)	Torsion test	Annexure-A
(o)	Ozone Resistance test	IEC 61854; Clause 7.6.3 (on thin rectangular test strip clamped at a static elongation of 20%)
(p)	Pull-off test	IS 16784

(q)	Water diffusion test on the core with housing	IS 16784
(r)	Peel test	IS 16784
(s)	Shear Test	IS 16784
(t)	Hydrophobicity Transfer Test	IS 16784

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 Insulator Units

a)	Verification of dimensions	IS 16784
b)	Galvanising test	IEC 60383
c)	Verification of end fittings	IS 16784
d)	Recovery of Hydrophobicity	Annexure-A
e)	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IS 16784
f)	Tests on interfaces and connections of metal fittings	IS 16784
g)	Silicone content test	Annexure-A
h)	Stress corrosion Test	IS 16784
i)	Dye Penetration Test	IS 16784
j)	Water Diffusion Test	IS 16784
k)	Hardness test	IS 16784
l)	Pull-off test	IS 16784
(m)	Water diffusion test on the core with housing	IS 16784
(n)	Peel test	IS 16784
(o)	Shear Test	IS 16784
(p)	Hydrophobicity Transfer Test	IS 16784

The test 4.2.1 (f) to (l) and 4.2.1 (p) 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 IS 16784.

4.3 Routine Tests

4.3.1 **For Composite Long Rod Insulator Units**

a)	Visual Examination	IS 16784
b)	Mechanical routine test	IS 16784

4.4 Tests During Manufacture

On all components as applicable

a)	Chemical analysis of zinc used for galvanizing	Annexure-A
b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	Annexure-A
c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	Annexure-A
d)	Tracking and erosion test on insulating material	IEC 60587
e)	SEM (Scanning Electron Microscopic) Analysis with EDS (Energy Dispersive Spectroscopy) on FRP rod cross-section, Surface analysis by optical spectrograph, FTIR Signature analysis	Annexure-A

4.5 Testing Expenses

4.5.1 In the event of type testing, Bidder shall ensure that adequate facilities are available in the proposed laboratories and the tests can be completed in these laboratories within the time schedule.

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 & repeat all the type tests once or to repeat that particular type test at least three times successfully at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

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/ equipment to be ready for testing, the expenses incurred by the Purchaser for re-deputation shall be deducted from contract price.

4.5.4 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.

4.5.5 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, except for the expenses of the inspector/ Purchaser's representative.

4.5 **Sample Batch for Type Testing**

4.5.5 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.

4.5.6 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Purchaser's representative. However, those acceptance tests, which are also required to be carried out afresh as type test, shall not be required to be carried out as acceptance test for sample selection for type testing.

4.6 **Schedule of Testing**

4.6.5 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.

4.7 **Additional Tests**

4.7.5 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 complies with the Specifications.

4.7.6 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.

4.8 **Guarantee**

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

4.9 **Test Reports**

4.9.5 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.

4.9.6 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.

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

4.9.8 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.

4.10 **Inspection**

4.10.5 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.

4.10.6 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.

4.10.7 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.

4.10.8 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.

4.10.9 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 is later found to be defective.

4.11 **Packing and Marking**

4.11.5 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.

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

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

4.11.8 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.

4.11.9 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.

4.11.10 #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)

4.12 **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.

4.12.5 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	Specification for zinc	
2	IS 406	Method of Chemical Analysis of Slab Zinc	
3	IS 731	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	
4	IS 2071 Part (I), Part(II) Part(III)	Methods of High Voltage Testing	
5	IS 2486 Part- I Part- II Part-III	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	
6	IS 2629	Recommended Practice for Hot, Dip Galvanisation for iron and steel	
7	IS 2633	Testing of Uniformity of Coating of zinc coated articles	
8	IS 6745	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	
9	IS 8263	Methods of RI Test of HV insulators	
10	IS 8269	Methods for Switching Impulse test on HV insulators	
11		Thermal Mechanical Performance test and mechanical performance test on string insulator units	IEC 60575
12		Salt Fog Pollution Voltage Withstand Test	IEC 60507
14		Selection and dimensioning of high voltage insulators intended for use	IEC 60815-**3**

Sl. No.	Indian Standard	Title	International Standard
		in polluted conditions: Polymer Insulators for AC systems	
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	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 10017 U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

Annexure-A

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	94 140 F****	1 1 1	5 1 -	1 2 3
Single I Suspension	60 90 F****	1 1 1	5 1 -	1 2 3
Single Tension	60 90 F****	1 1 1	5 1 -	1 2 3
Double Tension	120 180 F****	1 1 1	5 1 -	1 2 3
220 kV (SINGLE ZEBRA)				
Single I Suspension	47 70 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	47 70 F****	1 1 1	5 1 -	1 2 3
Double I Suspension	94 140 F****	1 1 1	5 1 -	1 2 3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Double Tension	160 240 F****	1 1 1	5 1 -	1 2 3
220 kV (TWIN MOOSE)				
Single I Suspension	80 120 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	80 120	1 1	5 1	1 2

	F****	1	-	3
Single Tension	80 120 F****	1 1 1	5 1 -	1 2 3
Double Tension	214 320 F****	1 1 1	5 1 -	1 2 3
400kV (TWIN MOOSE/ HTLS)				
Single V	80 60 90 F****	2 1 1 1	5 5 1 _	1 2 3 4
Single I Suspension (120kN)	80 120 F****	1 1 1	5 1 -	1 2 3
Single I Suspension (160kN)	107 160 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot (120 KN)	80 120 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot (160 KN)	107 160 F****	1 1 1	5 1 -	1 2 3
Single Tension (120 KN)	80 120 F****	1 1 1	5 1 -	1 2 3
Single Tension (160 KN)	107 160 F****	1 1 1	5 1 -	1 2 3
Double Tension (2X160kN)	214 320 F****	1 1 1	5 1 -	1 2 3
Double Tension (2X210kN)	280 420 F****	1 1 1	5 1 -	1 2 3
400kV (TRIPLE SNOWBIRD)				
Double I Suspension	161 240 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot	80 120	1 1	5 1	1 2

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

Double I	160 240 F****	1 1 1	5 1 1	1 2 3
Single V	155 130 130 210 F****	2 3 4 3 3	5 5 5 1 _	1 2 3 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 (2X160kN)	214 320 F****	1 1 1	5 1 -	1 2 3
Double I Suspension (2X210kN)	280 420 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot (1 x 160 kN)	107 160 F****	1 1 1	5 1 -	1 2 3
Single I Suspension Pilot (1 x 210 kN)	140 210 F****	1 1 1	5 1 -	1 2 3
Single Tension (1 x 160 kN)	107 160 F****	1 1 1	5 1 -	1 2 3
Single Tension (1 x 210 kN)	140 210 F****	1 1 1	5 1 -	1 2 3
Quad Tension	560	1	5	1

(4X210kN)	840 F****	1 1	1 -	2 3
Quad Tension (4X320kN)	856 1280 F****	1 1 1	5 1 -	1 2 3
±800kV HVDC				
Single 'Y' suspension	340 250 250 420 F****	2 3 4 3 3	5 5 5 1 -	1 2 3 4 5
Triple Tension String	845 1260 F****	1 1 1	5 1 -	1 2 3
Single I Pilot	108 160 F****	1 1 1	5 1 -	1 2 3
132kV Metallic Return Strings				
Single I	108 160 F****	1 1 1	5 1 -	1 2 3
Double Tension	242 420 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 V-string
4. Following with respect to vertical, half the string angle +15 deg, along the axis of one of the arm of the V-string

***: 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 each sub-conductor tensioned at 25% of conductor UTS shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductor 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 160 kg/m^3 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.

For ±800kV HVDC, the D.C. pollution withstand voltage (negative) shall be 800 kV as applicable at average ESDD of 0.1 mg / sq. cm. The test is to be performed on Single suspension 'Y' String and Triple tension string preferably in the same configuration. However, in case of laboratory limitations to carry out the test in tension mode for Triple tension strings, the test may be carried out in vertical mode at the same ESDD level.

2.0 Composite Longrod Insulator Units

2.1 Recovery of Hydrophobicity & Corona 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 Hydrophobicity classification. Dry the sample surface.

(2) The sample shall be subjected to mechanical stress by bending the sample over a ground electrode. Corona is continuously generated by applying 12 kV to a needle like electrode placed 1mm above the sample surface. The test shall be done for 100 hrs.

(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.

2.2 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 rms for 132 KV, 460kV rms for 220 KV & Metallic return insulators, 680 kV rms for 400 KV & 830kV rms for 765 KV Lines and 1 minute DC withstand test at -500 kV DC for ±500 kV HVDC & -800 kV DC for ±800kV HVDC insulators.

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 IS 16784.

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.

3.4 **Tests on FRP rod and silicon rubber compound**

The SEM (Scanning Electron Microscopic) Analysis with EDS (Energy Dispersive Spectroscopy) on FRP rod cross-section, Surface analysis by optical spectrograph & FTIR Signature analysis will be as per internationally recognized procedures for these tests. The details regarding test will be as discussed and mutually agreed to by the Supplier and Purchaser in Quality Assurance Programme

Annexure-B

A) Standard Technical Particulars of Composite Long Rod Insulator unit:

1. For Transmission Line upto 400 kV

Sl. No.	Description	Unit	132 kV AC	220 kV AC (single ZEBRA)		220 kV AC (Twin MOOSE)		400kV			
			90 KN	70 KN	120 KN	120KN	160KN	90KN	120KN	160KN	210KN
1	Size and Designation of Ball & Socket assembly	mm	16 mm (Alt-B)	16 mm (Alt-B)	20 mm	20 mm	20 mm	16mm (Alt-B)	20 mm	20 mm	24 mm
2	Core diameter*	mm	20	20	20	20	24	20	20	24	24
3	Nominal length	mm	1450	2030	2175	2030	2210	3375	3375	3910	3910
4	Minimum Creepage distance	mm	4495	7595	7595	7595	7595	13020	13020	13020	13020
5	No. of grading rings (min.)	Nos.	1	1	1	1	1	2	2	2	2
6	Nominal Outer Diameter of grading ring										
a)	Covered ring ***	mm	NA	NA	NA	NA	NA	300	300	300	300
b)	Other rings (Open type)	mm	200	200	200	200	200	300	300	300	300
7	Depth of grading ring (open type)	mm	105-125	105-125	105-125	105-125	140-150	105-125	105-125	140-150	140-150

2. For Transmission Line above 400 kV

Sl. No.	Description	Unit	765kV				± 500kV HVDC		± 800kV HVDC		Metallic return for ± 800kV HVDC	
			120 KN	160 KN	210 KN	320 KN	160 KN	210 KN	160 KN	420 KN	160 NN	210 KN
1	Size and Designation of Ball & Socket assembly	mm	20 mm	20 mm	24mm	24 mm	20 mm	24mm	20 mm	28mm	20 mm	24mm
2	Core diameter*	mm	20	24	24	32**	24	24	24	34	24	24
3	Nominal length	mm	2900	2975	2975	2975	3485/ 3230	3485	4560	4560	2550	2550
4	Minimum Creepage distance	mm	12400	12400	12400	12400	13750	13750	16800	16800	8000	8000
5	No. of grading rings (min.)	Nos.	2	2	2	2	2	2	2	2	2	2
6	Nominal Outer Diameter of grading ring											
a)	Covered ring ***	mm	300	300	300	300	300	300	As per Manufacturers' specification			
b)	Other rings (Open type)	mm	370	370	370	370	370	370	As per Manufacturers' specification			
7	Depth of grading ring (open type)	mm	125-155	125-155	140-155	As per Manufacturers' specification						

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.*

***For offered core dia, less than indicated in table above, the bidder shall submit documentary evidence of past supplies & satisfactory operation of the same for minimum period of three years. However, the overall string length shall be within the limits specified in the drawing.*

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

B) Standard Technical Particulars of Insulator Strings

1. For 132 kV Transmission Line

Sl. No.	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.	1 x 1	2 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	275			
3.0	Impulse withstand voltage (dry)					
a)	Positive	kV_p	650			
b)	Negative	kV_p	650			
4.0	Dry Arcing distance	mm	1200			
5.0	Mechanical strength	KN	90	2 x 90	90	2 x 90

2. For 220 kV Transmission Line

a) For 220 kV Transmission Line with single ZEBRA/HTLS conductor

Sl. No.	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.	1 x 1	1 x 1	2 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	460				
3.0	Impulse withstand voltage (dry)						
a)	Positive	kV_p	1050				
b)	Negative	kV_p	1050				
4.0	Dry Arcing distance	mm	1800				
5.0	Mechanical strength	KN	70	70	2X 70	120	2 x 120

b) For 220 kV Transmission Line with twin MOOSE conductor

Sl. No.	Description	Unit	Standard Technical Particular value			
			Single 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Double Tension
1.0	**No. of Insulator Units**	**Nos.**	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	460			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV_p	1050			
b)	Negative (Peak)	kV_p	1050			
5.0	Dry Arcing distance	mm	1800			
6.0	Mechanical strength	kN	120	120	120	2 x 160

3. For 400 kV Transmission Line

a) 400 kV Transmission Line with twin MOOSE/ HTLS Conductor

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.**	2 x 1	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(Wet)						
a)	Positive (Peak)	kV_p	1050				
b)	Negative (Peak)	kV_p	1050				
4.0	Impulse withstand voltage (dry)						
a)	Positive (Peak)	kV_p	1550				
b)	Negative (Peak)	kV_p	1550				
5.0	Dry Arcing distance	mm	3050				
6.0	Mechanical strength	kN	90	120/ 160	120/ 160	120/ 160	2 x160/ 2 x 210

b) 400 kV Transmission Line with twin ACSR LAPWING Conductor

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Single 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Double Tension
1.0	**No. of Insulator Units**	**Nos.**	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(Wet)					
a)	Positive (Peak)	kV_p	1050			
b)	Negative (Peak)	kV_p	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV_p	1550			
b)	Negative (Peak)	kV_p	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	160	160	160	2 x 210

c) 400 kV Transmission Line with triple ACSR SNOWBIRD Conductor

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					
a)	Positive (Peak)	kV_p	1050			
b)	Negative (Peak)	kV_p	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV_p	1550			
b)	Negative (Peak)	kV_p	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2 x 120	120	120	2 x 210

d) 400 kV Transmission Line with quad MOOSE Conductor

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(Wet)					
a)	Positive (Peak)	kV_p	1050			
b)	Negative (Peak)	kV_p	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV_p	1550			
b)	Negative (Peak)	kV_p	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2 x 120	120	120	4 x 160

4. For 765 kV Transmission Line

a) 765 kV Single Circuit Transmission Line

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

b) 765 kV Double Circuit Transmission Line

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 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(Wet)					
a)	Positive (Peak)	kV_p	1550			
b)	Negative (Peak)	kV_p	1550			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV_p	2400			
b)	Negative (Peak)	kV_p	2400			
5.0	Dry Arcing distance	mm	5100			
6.0	Mechanical strength	kN	2 x 160/ 2 x 210	160/ 1 x 210	160/ 1 x 210	4 x 210/ 4 x 320

5. For ± 500kV HVDC Transmission Line

a) ± 500kV HVDC Line with quad ACSR BERSIMIS Conductor

Sl. No	Description	Unit	Standard Technical Particular Value	
			Single 'V' Suspension string	Quad Tension string
1.0	No. of Insulator Units	Nos.	2 x 2	4 x 2
2.0	DC withstand voltage under wet condition	kV	550 (negative)	
3.0	Impulse withstand voltage (dry)			
a)	Positive (Peak)	kV_p	1800	
b)	Negative (Peak)	kV_p	1800	
4.0	Switching Withstand voltage (Wet)			
a)	Positive (Peak)	kV_p	1000	
b)	Negative (Peak)	kV_p	1000	
5.0	Dry Arcing distance	mm	3050	
6.0	Mechanical strength	kN	2 x 210	4 x 160

b) ± 500kV HVDC Line with quad ACSR LAPWING Conductor

Sl. No	Description	Unit	Standard Technical Particular Value	
			Single 'V' Suspension string	Quad Tension string
1.0	No. of Insulator Units	Nos.	2 x 2	4 x 2
2.0	DC withstand voltage under wet condition	kV	550 (negative)	
3.0	Impulse withstand voltage (dry)			
a)	Positive (Peak)	kV_p	1800	
b)	Negative (Peak)	kV_p	1800	
4.0	Switching Withstand voltage (Wet)			
a)	Positive (Peak)	kV_p	1000	
b)	Negative (Peak)	kV_p	1000	
5.0	Dry Arcing distance	mm	3050	
6.0	Mechanical strength	kN	2 x 210	4 x 210

6. For ± 800kV HVDC Transmission Line

Sl. No.	Description	Unit	± 800kV HVDC Strings			132kV Metallic Return Strings	
			Single 'Y' Suspension string	Triple Tension string	Single I Suspension Pilot string	Single 'I' Suspension string	Double Tension string
1.0	No. of Insulator Units	Nos.	2x2 (V-portion) & 1x2 (II-portion)	3 x 3	1 x 3	1 x 1	2 x 1
2.0	Mechanical strength of complete insulator string along with hardware fittings	kN	420 (along one limb of V-portion and along II portion)	3 x 420	1 x 160	160	2 x 210
3.0	DC withstand volt-age for DC/ Power frequency withstand voltage for metallic return of string with arcing horns, corona control rings/ grading rings under wet condition	kV (rms)	800 (negative)			460	
4.0	Impulse withstand voltage (dry)						
a)	Positive (Peak)	kV_p	2250			1050	
b)	Negative (Peak)	kV_p	2250			1050	
5.0	Switching Withstand voltage (Wet)						
a)	Positive (Peak)	kV_p	1850			NA	
b)	Negative (Peak)	kV_p	1850			NA	
6.0	Minimum corona extinction voltage under dry condition	kV	880			NA	
7.0	Radio interference voltage at one MHZ when the string subjected to conductor surface gradient of 22kV/cm (±DC)	Micro volt	<1000			NA	
8.0	DC pollution withstand voltage test	kV	800 (negative)			NA	