BHARAT HEAVY ELECTRICALS LIMITED

TRANSMISSION BUSINESS ENGINEERING MANAGEMENT

NEW DELHI

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TITLE	400KV & 220KV COMPOSITE LONG ROD POLYMER INSULATORS STRING AND HARDWARE FITTING			DATE	14-12-17		14-12-17
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CUSTOMER	**POWER GRID CORPORATION OF INDIA LIMITED**
PROJECT	Substation Package -SS01 for Construction of 765/400/220kV Bhuj Pool (New) S/S and Extension of 765kV Banaskantha S/S under Green Energy Corridors: Inter-State Transmission Scheme (ISTS) – Part C.[Part-2]
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SECTION - 1

1.1 SCOPE

This technical specification covers the requirements of design, manufacture, testing at works, packing and dispatch of 400kV composite long rod polymer insulators string and hardware fitting to site.

The specification comprise of following sections:

Section-1: Scope, Specific Technical Requirements & Bill of Quantities
Section-2: Detailed Technical Requirement - Equipment Specification
Section-3: Project Details & General Technical Requirements
In case of any conflict between various sections, order of precedence shall be in the same order as listed above

This section covers the scope and quantities of 400kV composite long rod polymer insulators string and hardware fitting. The Specific Technical Requirements for the above item as specified by the customer (PGCIL) are given in Section-2. The offered equipment shall also comply with the General Technical Requirements for the project as detailed under section-3 of this specification.

The equipment is required for the following project:

Customer: Power Grid Corporation of India Ltd.

Project: Substation Package -SS01 for Construction of 765/400/220kV Bhuj Pool (New) S/S and Extension of 765kV Banaskantha S/S under Green Energy Corridors: Inter-State Transmission Scheme (ISTS) – Part C.[PART-2]

1.2 SPECIFIC TECHNICAL REQUIREMENTS-

All equipments shall perform satisfactorily under various other electrical, electromechanical and meteorological conditions of the site of installation.

All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) etc for the equipment.

Equipment's and system shall be designed to meet the following major technical parameters as brought out hereunder.

SN	Parameters	400kV	220kV
1.	Max. System Voltage (kV)	420kV	245kV
2.	Lightning Impulse withstand voltage of string with corona control rings (dry) (kVp)	± 1550	± 1050
3.	Switching surge withstand voltage of string with corona control ring (wet) (kVp)	± 1050	N/A
4.	Power frequency withstand voltage of the complete string with corona control rings (wet (kVrms)	680	460
5.	Minimum total creepage distance of the insulator string (mm)	**13020 mm (31mm/kV)**	**7595 (31mm/kV)**
6.	Max. Radio Interference voltage in micro volts of string with corona control rings across 300 Ohms resistor at 1 Mhz	1000(Max.) at 320kV	1000(Max.) at 156kV
7.	Minimum Corona Extinction Voltage level of string with corona control rings (dry) (kV rms)	320	156
8.	Ball and sockets designation of the Insulator string in mm	**20**	**20**
9.	Hot dip galvanizing	As per IS 2633/2629	As per IS 2633/2629
10.	Electro mechanical strength of composite long rod insulator unit in (kN)	**120**	**120**
11.	System Fault Level	**63kA for 1 Sec**	**40kA for 1 Sec**

1.3 BILL OF QUANTITIES – FOR BHUJ SS

1.3.1 400 KV STRING MATERIAL

Sl. No	Description	Unit	QTY
1	**400KV, 120KN COMPOSITE LONG ROD POLYMER TYPE INSULATOR WITH CREEPAGE DISTANCE OF 31MM/KV.**	Nos.	18
2	400 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR SINGLE SUSPENSION STRING ARRANGEMENT WITH DROP TYPE SUSPENSION CLAMP (ANCHOR SPACING OF 450MM) SUITABLE FOR TWIN BERSIMIS CONDUCTOR (SUB CONDUCTOR SPACING 450MM). SUITABLE FOR 120KN COMPOSITE LONG ROD POLYMER TYPE INSULATOR. EKD ID D48	Sets	6
3	400 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR SINGLE SUSPENSION STRING ARRANGEMENT WITH DROP TYPE SUSPENSION CLAMP (ANCHOR SPACING OF 450MM) SUITABLE FOR QUAD BERSIMIS CONDUCTOR (SUB CONDUCTOR SPACING 450MM). SUITABLE FOR 120KN COMPOSITE LONG ROD POLYMER TYPE INSULATOR. EKD ID - D44	Sets	12

1.3.2 220 KV STRING MATERIAL

Sl. No	Description	Unit	QTY
3	**220KV, 120KN COMPOSITE LONG ROD POLYMER TYPE INSULATOR WITH CREEPAGE DISTANCE OF 31MM/KV.**	Nos.	282
4	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR DOUBLE TENSION POLYMER LONG ROD INSULATOR WITH TURN BUCKLE SUITABLE FOR QUAD BERSIMIS THROUGH TYPE (CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S1	Set	27
5	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR DOUBLE TENSION POLYMER LONG ROD INSULATOR W/O TURN BUCKLE SUITABLE FOR QUAD BERSIMIS THROUGH TYPE (CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S2	Set	27
6	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR SINGLE SUSPENSION POLYMER POLYMER LONG ROD INSULATOR WITH THROUGH TYPE CLAMP SUITABLE FOR QUAD BERSIMIS (CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S3	Set	15

7	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR DOUBLE TENSION POLYMER LONG ROD INSULATOR WITH TURN BUCKLE SUITABLE FOR TWIN BERSIMIS THROUGH TYPE(CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S5	Set	33
8	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR DOUBLE TENSION POLYMER LONG ROD INSULATOR W/O TURN BUCKLE SUITABLE FOR TWIN BERSIMIS THROUGH TYPE (CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S6	Set	33
9	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR SINGLE SUSPENSION POLYMER POLYMER LONG ROD INSULATOR WITH THROUGH TYPE CLAMP SUITABLE FOR TWIN BERSIMIS (CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S7	Set	18
10	220 KV HARDWARE ASSEMBLY COMPLETE IN ALL RESPECT FOR SINGLE SUSPENSION POLYMER POLYMER LONG ROD INSULATOR WITH DROP CLAMP SUITABLE FOR TWIN BERSIMIS (CONDUCTOR SPACING 250MM AND ANCHOR SPACING 450MM) (120 kN) (CREEPAGE 31MM / KV) EKD ID - S8	Set	6

NOTE:

1) Individual quantity may vary up to any extend, however total contract value may vary upto ±30%.
2) Supply of all the hardware are deemed to be included including corona rings whereas applicable.

1.1 TYPE TESTING-

Bidder shall submit valid type test reports (as per relevant IEC/IS Standard) for approval. The type test reports submitted shall be of tests conducted within last 10 years prior to the date of bid opening i.e. dated **07.04.2015.** The bidder should have conducted type test on identical or similar equipment/ components to those offered. In case type test reports are found to be technically unacceptable to BHEL/PGCIL, the type test shall be conducted without cost and delivery implication to BHEL.

1.2 QUALITY PLAN-

Bidder to follow valid PGCIL approved Quality Plan as per PGCIL procedure. In case the bidder don't have valid PGCIL approved QP, it will be the bidder's responsibility

to get its QP approved directly from the ultimate customer.

1.6 QUALIFYING REQUIREMENTS OF COMPOSITE LONG ROD POLYMER INSULATOR STRING (400kV) -

The manufacturer whose composite long rod insulator strings are offered should have been manufacturing composite long rod insulator for the last five years as on the originally scheduled date of bid opening. The manufacturer(s) should have also designed , manufactured , tested and supplied composite long rod insulator strings of 120kN or above electro mechanical strength for specified voltage or above and the same should have been in operation as on the originally scheduled date of bid opening.

Further, the manufacturer should also have successfully completed the following tests on the insulator units and insulator strings (of composite long rod insulators) as on the originally scheduled date of bid opening dated **07.04.2015:**

i) Tests on individual units as per IEC 61109

ii) Following type tests on insulator strings assembly for the specified voltage or above class transmission lines/substations with 120kN or above electromechanical strength insulators:

-power frequency voltage withstand test (wet)

-Switching Surge voltage withstand test (wet)

-Lightning Impulse voltage withstand test (dry)

-Radio interference voltage test (dry)

iii) Accelerated ageing test of 5000 hours as described in appendix-C of IEC 61109 or test at multiples stresses of 5000 hours as described in Annex-B of IEC-62217.

Note: Originally scheduled date of bid opening is dated **07.04.2015**

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SECTION-2

SECTION-(SE)
SWITCHYARD ERECTION

2.0 **String Insulators & Hardware**

The insulators for suspension and tension strings shall conform to IEC-60383 and long rod insulators shall conform to IEC-60433. Insulator hardware shall conform to IS:2486. Composite long rod **polymer** insulator shall conform to IEC:61109. **Further, contractor shall supply insulators as per details mentioned below:**

765 kV & 400 kV System	220 kV & 132kV System
Porcelain/Glass/ Composite Long Rod Polymer	Porcelain/Glass/composite Long Rod Polymer/Porcelain long Rod

2.1 Construction Features (Porcelain & Glass Insulators)

2.1.1 **Porcelain insulators**

a) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have rated strength **manufacturer's logo, month & year of manufacturing** markings on porcelain printed and applied before firing.

b) Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and

impervious to moisture.

c) Glazing of the porcelain shall be uniform brown colour, free from blisters, burrs and other similar defects.

2.1.2 **Glass insulators (upto 765kV voltage level)**

It **shall** be made of toughened glass. Glass used for the shells shall be sound, free from defects, flows bubbles, inclusions, etc and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

2.1.2.1 When operating at normal rated voltage, there shall be no electric discharge between conductor and insulator which would cause corrosion or **damage** to conductors or insulators by the formation of substances due to chemical action. No radio interference shall be caused when operating at normal rated voltage.

2.1.2.2 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanized in accordance with the latest edition of IS: 2629. The zinc used for galvanizing shall be of grade Zn-99.95 as per IS-209. 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.

2.1.2.3 Contractor shall make available data on all the essential features of design including the method of assembly of discs and metal parts, number of discs per insulator string, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.

2.1.2.4 Clamps for insulator strings and Corona Control rings shall be of aluminium alloy as stipulated for clamps and connectors.

2.1.2.5 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.

2.1.2.6 The tension Insulator hardware assembly shall be designed for minimum 21000 kg tensile load for 765kV and minimum 12000 kg tensile load for **hardware assembly** below 765kV. Earth wire tension clamp shall be designed for minimum 1000 kg tensile load with a factor of safety of two (2).

2.1.2.7 The tension string assemblies shall be supplied alongwith suitable turn buckle. Sag compensation springs if required may also be provided.

2.1.2.8 All hardware shall be bolted type.

2.1.3 **Long Rod Porcelain Insulators (up to 220kV Voltage level)**

2.1.3.1 As an alternative to disc insulator, Bidder can offer long rod porcelain insulators strings, with suitable hardware. The combination should be suitable for

application specified and should offer the identical/equivalent parameters as would be available from insulator string comprising disc insulators and hardware combination.

2.1.3.2 All constructional features specified at Clause **2.1.1** of this Section shall also apply to the long rod insulator string.

2.2 Tests

In accordance with the stipulations of the specification, the suspension and tension strings, insulator and hardware shall be subjected to the following type tests, acceptance tests and routine tests:

2.2.1 **Type Tests on Insulator Strings:** The test reports for following type tests shall be submitted for approval as per clause 9.0 of Section - GTR.

a) Power frequency voltage withstand test with corona control rings **(if applicable)** under wet condition as per IEC- 60383.

b) Switching surge voltage withstand test [400 kV and above class only] under wet condition as per IEC-60383.

c) Lightning Impulse voltage withstand test with corona control rings under dry condition as per IEC-60383

d) Voltage distribution test (Dry) **[applicable for disc insulator string only]**

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage. The voltage across any disc shall not exceed 6.5% for 765 kV suspension and tension insulator strings, 9% and 10% for 400KV suspension string and tension insulator string respectively, 13% for 220KV suspension and tension insulator strings, 20% and 22% for 132KV suspension and tension insulator strings respectively.

e) Corona Extinction Voltage test (Dry) [132kV and above class only]

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage **as specified at clause 2.3.2**. 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.

f) RIV Test (Dry) [132 kV and above class only]

Under the conditions as specified under (e) above the insulator string alongwith complete hardware fittings shall have a radio interference voltage as **specified in clause 2.3.2 of this section.** The test procedure shall be in accordance with IS 8263/IEC 60437.

g) Mechanical strength test: The test shall be carried out as per following procedure.

The complete insulator string alongwith its hardware fitting excluding

arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.2.2 **Type Tests on Insulators**

Type test report for Thermal Mechanical Performance tests **(applicable for porcelain type insulators)** as per IEC - 60575, Clause 3 shall be submitted for approval as per clause 9.2 of Section - GTR.

2.2.3 **Acceptance Tests for Insulators:**

a) Visual examination as per IEC-60383/ IEC-61109 clause no. 7.2 (for composite long rod insulators).

b) Verification of Dimensions as per IEC- 60383.

c) Temperature cycle test as per IEC- 60383.

d) Puncture Test as per IEC-60383 (Applicable only for porcelain insulators).

e) Galvanizing Test as per IEC- 60383.

f) Mechanical performance test as per IEC-60575 Cl. 4 / IEC-61109 clause no. 7.2 (for composite long rod insulators).

g) Test on locking device for ball and socket coupling as per IEC-60372(2).

h) Porosity test as per IEC- 60383 (Applicable only for porcelain insulators).

i) Thermal shock test as per IEC-60383 (Applicable only for glass insulators)

2.2.4 **Acceptance Test on Hardware Fitting**

a) Visual Examination as per Cl. 5.10 of IS: 2486 (Part-I).

b) Verification of Dimensions as per Cl. 5.8 of IS:2486 (Part-I)

c) Galvanising/Electroplating tests as per Cl. 5.9 of IS:2486 (Part-I).

d) Slip strength test as per Cl 5.4 of IS-2486 (part-I)

e) Shore hardness test **by** the Elastometer (if applicable as per the value

guaranteed by the Bidder).

f) Mechanical strength test for each component (including corona control rings and arcing horns).

The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in **2.2.1.(g)** above should be followed.

g) Test on locking devices for ball and socket coupling as per IEC -60372(2).

2.2.5 **Routine Test on Insulator**

a) Visual Inspection as per IEC-60383

b) Mechanical Routine Test as per IEC-60383

c) Electrical Routine Test as per IEC-60383

2.2.6 **Routine Test on hardware Fittings**

a) Visual examination as per Cl 5.10 of IS:2486 (Part-I)

b) Mechanical strength Test as per Cl. 5.11 of IS:2486 (Part-I)

2.2.7 **Test during manufacture on all Components as applicable on insulator**

a) Chemical analysis of zinc used for galvanising:

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

b) Chemical Analysis, mechanical hardness tests and magnetic particle inspection for malleable casting:

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting 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 tests will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Program.

2.2.8 **Test during manufacture on all components as applicable on hardware fittings:**

a) Chemical analysis of zinc used for galvanising:

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

b) Chemical analysis, hardness tests and magnetic particle for Forgings/ **fabricated hardware:**

The chemical analysis, hardness tests and magnetic particle inspection

for forgings/fabricated hardware 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 tests will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

2.3 Guaranteed technical Particular For

2.3.1 **Disc Insulators**

Sl. No.	Description	For 765kV	For 400/220/132kV
a)	Type of insulators	Anti Fog type	Anti Fog type
b)	Size of insulator units (mm) **(Dia & Height)**	255x145 or 280x145	255x145 or 280x145
c)	Electro mechanical strength	210 kN	120 kN
d)	Creepage distance of individual insulator units (minimum and as required to meet total creepage distance)	460 mm	430 mm
e)	Markings		
i)	For Porcelain insulators	Markings on porcelain	Markings on porcelain
ii)	For toughened glass insulators	Markings shall be done on initial parts	Markings shall be done on initial parts
f)	Power frequency puncture withstand voltage	1.3 times the actual wet flashover voltage	1.3 times the actual wet flashover voltage

2.3.2 **INSULATOR STRING**

Sl. No.	Description	765 kV	400kV	220kV	132kV
a)	Power frequency withstand voltage of the complete string with corona control ring (wet) – KV rms	870	680	460	275
b)	Lightning impulse withstand Voltage of string with corona control rings (dry) - kVp	± 2100	± 1550	± 1050	± 650
c)	Switching surge withstand voltage of string with corona control rings (wet) - kVp	± 1550	± 1050	NA	NA
d)	Minimum corona extinction voltage level of string with Corona Control rings (dry) - kV rms	508	320	156	NA
e)	Maximum RIV level in micro volts of string with Corona Control rings across 300 Ohms resistor at 1 MHz	**1000** (Max) **at 508**	1000 (Max) **at 320**	1000 (Max) **at 156**	NA

		kV	kV	kV	
f)	Minimum total creepage distance of the insulator string (mm)	~~20000~~	~~10500~~ 13020	~~6125~~ 7595	~~3625~~
~~g)~~	~~Total no. of discs per string~~	~~44~~	~~25~~	~~15~~	~~10~~
h)	Electromechanical strength of Insulator Unit. (KN)	210	120	120	120

For tension application, double insulator strings for 765kV, 400kV, 220kV and single insulator strings for 132 kV systems shall be used. For suspension purpose single suspension insulator string shall be used for 765kV, 400kV, 220kV & 132 kV systems. In case of polymer insulator, Bidder shall offer 'V' suspension strings without any extra cost implication.

2.4 COMPOSITE LONG ROD INSULATOR

As an alternative to disc insulator/long rod porcelain, Bidder can also offer composite long rod **polymer** insulators with suitable hardware.

2.4.1 Details of Composite Long Rod Insulators

2.4.2 Contractor shall offer such composite insulators which have proven use under foggy/ humid **operating** conditions in polluted industrial environment combined with smoke and dust particles.

2.4.3 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.

2.4.4 Ball and socket shall be 20mm designation for 120kN & 24mm designation for 210kN Insulators in accordance with the standard dimensions stated in IEC:60120/ IS:2486 (Part-II). Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings. Each insulator shall have **laser markings on housings for manufacturer's name, month & year of manufacturing**, rated strength markings on each composite insulator rod unit. **No** negative tolerance shall be applicable to creepage distance of composite insulators

2.4.5 **All ferrous parts shall be hot dip galvanized as per Section-GTR with minimum weight of zinc coating as 610 gm/sq.m**.

2.4.6 Materials

2.4.6.1 Core

It shall be a glass-fiber reinforced (FRP) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. 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.

2.4.6.2 Housing & Weathersheds

The FRP rod shall be covered by a sheath of a silicone rubber compound of a

thickness of minimum **5mm**. The housing & weathersheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. 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 weathersheds of the insulators shall be of alternate shed profile. The weathersheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection moulding 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 weathershed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

2.4.6.3 **End Fittings**

End fittings transmit the mechanical load to the core. They shall be made of malleable cast iron/ spheroidal graphite or forged steel. 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 gap between fitting and sheath 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.

2.4.6.4 **Grading Rings**

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce TV noise to acceptable levels. 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. 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 **rings**. 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.

2.4.7 **Tests and Standards**

2.4.7.1 **Type Tests**

The test reports for following type tests on long rod units, components, materials or complete strings shall be submitted for approval as per clause 9.2 of Section - GTR.

2.4.7.1.1 **On the complete composite Long Rod Insulator String with Hardware Fittings**:-

a) Power frequency voltage withstand test with corona control rings/grading ring and arcing horns (if provided) under wet condition as per IEC:60383-1993/

b) Switching surge voltage withstand test under wet condition as per IEC:60383-1993.

c) Impulse voltage withstand test under dry condition as per IEC:60383-1993

d) Corona and RIV test under dry condition. [132kV and above class only]

The sample assembly when subjected to power frequency voltage shall have a corona extinction **voltage as specified in clause 2.3.2 of this section** 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.

Under the conditions as specified above the insulator string alongwith complete hardware fittings shall have a radio interference voltage level **as specified at specified in clause 2.3.2 of this section**.The test procedure shall be in accordance with IS 8263/IEC 60437.

e) Mechanical Strength test: The test shall be carried out as per following procedure.

The complete insulator string alongwith its hardware fitting excluding arcing horn, corona control ring, grading ring, tension/suspension clamps shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

f) Salt-fog pollution withstand test as per IEC: 60507. The salinity level for composite long rod insulators shall be 160 Kg/m3 **NaCl**.

2.4.7.1.2 **On Composite Insulator Units**

a) Tests on interfaces and connections of metal fittings as per IEC: 61109-2008.

b) Assembled core load time test as per IEC: 61109-2008.

c) Damage limit proof test and test of tightness of interface between end firings and insulator housing as per IEC: 61109-2008

d) High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm 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 **done by** 1 minute wet power frequency withstand test at 680kV r.m.s for 400KV.

e) Brittle fracture resistance test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO3 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.

f) Dye penetration test as per IEC: 61109-2008

g) Water diffusion test as per IEC: 61109-2008

h) Tracking and erosion test as per IEC: 61109-2008.

i) Hardness test as per IEC: 61109-2008.

j) Accelerated weathering test as per IEC: 61109-2008.

k) Flammability test as per IEC: 61109-2008.

l) Silicone content test

Minimum content of silicone **shall be 30% and the same** shall be verified through FT-IR spectroscopy & TGA analysis or any other approved/ **acceptable method**.

m) 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.

n) Torsion test

Three complete insulators of each **electrical and mechanical** rating shall be subjected to a torsional load of 55Nm. 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.

o) Accelerated ageing test of 5000hrs as described in appendix-C of IEC 61109 or Test at multiple stresses of 5000 hrs as described in Annex-B of IEC - 62217

2.4.7.2 **Acceptance Tests:**

For Composite Long Rod Insulators

a.	Verification of dimensions	IEC : 61109-2008
b.	Galvanizing test	IEC : 60383
c.	Verification of end fittings	IEC : 61109-2008
d.	Recovery of Hydrophobicity	As per above
e.	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC : 61109-2008
f.	Silicone content test	As per above
g.	Brittle fracture resistance test	As per above
h.	Dye penetration test	IEC : 61109-2008
i.	Water diffusion test	IEC : 61109-2008

In the event of failure of the sample to satisfy the acceptance test(s) specified in **2.4.7.2** above, the **re-test** procedure shall be as per IEC 61109.

2.4.7.3 **Routine Tests**

For Composite Long Rod Insulator Units

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

2.4.8 **Guaranteed Technical Particulars for Composite Long Rod Polymer Insulators**

The technical parameters for composite long rod polymer insulator string shall be same of the insulator string specified in clause 2.3.2 of this section.