National Transmission & Despatch Company Limited

Bidding Documents

AFD-TL01-2024

PROCUREMENT OF TRANSMISSION LINE MATERIAL FOR 500KV TRANSMISSION LINES ASSOCIATED WITH 500KV SIALKOT & VEHARI SUBSTATIONS

Volume-II: Technical Provisions

Single-Stage: One-Envelope
Bidding Procedure

Agence Française de Développement

Issued on: April 07**, 2024**

Invitation for Bids No.: **IFB-AFD-TL01-2024**

OCB No.: **AFD-TL01-2024**

Purchaser: **National Transmission & Despatch Company Limited**

Country: **Islamic Republic of Pakistan**

Table of Contents

VOLUME – II: TECHNICAL PROVISIONS

1. GENERAL

This section of Technical Provisions specifies the general technical requirements for galvanized latticed steel towers, OPGW, fog type Toughened Glass Insulators, Non Ceramic Composite Insulators, hardware for conductor & OPGW, spacer dampers, rigid spacers, grounding material & other related accessories to be used for this project.

1.1 MATERIAL AND WORKMANSHIP

1.1.1 MATERIALS

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, shall have suitable corrosion resistant characteristics and of the classification and grades designated, conforming to the requirements of the latest issue of the appropriate specifications cited herein.

1.1.2 WORKMANSHIP

Workmanship and general finish shall be of the highest grade, in accordance with the requirements specified herein, and the best modern standard practice.

All components of the same design and designation shall be identical and like components shall be interchangeable.

All necessary tests shall be performed to ensure that technical requirements are fulfilled.

1.1.3 STANDARDS

Unless otherwise specified in these Specifications or in the drawings, the Supplier shall conform to the applicable requirements of the latest revisions of the following standards or equivalent as approved by the Engineer. The latest applicable standards shall be those which are enforced thirty (30) days prior to the date of Bid opening and the same shall be provided on request of the Engineer.

1.1.3.1 Galvanized Latticed Steel Towers

a)	ASTM A6:	General Requirements for Rolled Steel Plates, Shapes, Sheet Piling and Bars for Structural use.
b)	ASTM A36:	Standard Specification for Structural Steel.
c)	GB/T 700	Carbon Structural Steels
d)	GB/T 1591	High Strength Low Alloy Structural Steels
e)	ASTM A572:	Grade 60 Standard Specification for High Strength Low-Alloy Columbium-Vanadium Steels of Structural Quality.
f)	EN 10025:	EURONORM Standard Specification for Structural Steel; Rolled Steel, Steel Sheets and Plates etc.

g)	ASTM A123:	Zinc (Hot Galvanized) coatings on products fabricated from rolled, pressed, and forged steel shapes, plates, bars and strip.
h)	ASTM A143:	Safe-guarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement.
i)	ASTM A563M:	Standard Specification for Carbon and Alloy Steel Nuts.
j)	ASTM A153:	Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware.
k)	ASTM A239:	Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).
l)	ASTM A325:	High-strength bolts for structural steel joints including suitable nuts and plain hardened washers.
m)	ASTM A370:	Standard test methods and definitions for mechanical testing of steel products.
n)	ASTM A384:	Standard practice for safe-guarding against warpage and distortion during Hot-dip Galvanizing of Steel Assemblies.
o)	ASTM A394:	Standard specification for Steel Transmission Tower Bolts, Zinc-coated and Bare.
p)	ASTM A673:	Standard specification for Sampling Procedure for Impact Testing of Structural Steel.
q)	ASTM A121:	Standard specification for metallic-coated carbon steel barbed wire.
r)	ASTM F436:	Standard specification for hardware steel washers.
s)	ASTM B201:	Chromatic treatment test.
t)	ASTM E 94:	Radiographic Testing.
u)	ASTM E109:	Dry powder magnetic particle inspection.
v)	ISO 898-1 & ISO 898-2:	Mechanical Properties of Fasteners made of carbon steel and alloy steel.
w)	DIN 267:	Fasteners technical delivery conditions steel spring washers for bolt/nut assemblies.

x)	DIN 7990:	Hexagon head bolts for structural steel bolting for supply with nut.
y)	DIN 555:	M5 to M100 x 6 hexagon nuts.
z)	DIN 127:	Spring lock washers with square ends or tang ends.
aa)	DIN 128:	Spring lock washers curved and wave.
bb)	ASTM A780M:	Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings.
cc)	ACSE Manual No.74:	Guidelines for Transmission Line Structural Loading" prepared and published by the American Society of Civil Engineers in 2010 (3rd Edition)
dd)	ASCE Standard 10-97:	"Design of Latticed Steel Transmission Structures".
ee)	Other applicable international standard	

1.1.3.2 OPGW and Associated Hardware

a)	ITU-T G.652:	Characteristics of a single-mode optical fiber cable.
b)	ITU-T G.654:	Characteristics of a cut-off shifted single-mode optical fiber cable.
c)	IEC 60793:	Optical fibers.
d)	IEC 60794:	Optical fiber cables.
e)	EIA 598A:	Color coding of optical fibers.
f)	ASTM B415:	Standard specification for hard-drawn aluminum-clad steel wires.
g)	ASTM B416:	Standard specification for Concentric-Lay-Stranded Aluminum-Clad Steel Conductors
h)	ASTM B398:	Standard Specification for Aluminum-Alloy 6201-T81 Wire for Electrical Purposes.
i)	IEEE Std. 1138:	Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for use on Electric Utility Power Lines.

j) IEC 61300-2-36 Fiber Optic Interconnection Devices & Passive component. Basic Test and Measurement Procedures. Tests. Flammability (Fire Hazard)

k) IEC 60068-2-14 Joint boxes/hardware fittings

l) EN 60529 Protection Class of cabinets/cubicles

m) Other applicable international standard

1.1.3.3 Insulator Hardware Assemblies

a) NTDC Specifications P-8b:2020 for Toughened Glass Disc Insulators.

b) ASTM A47 Specifications for Ferritic Malleable Iron Castings.

c) ASTM A143: Standard Recommended practice for safeguard against embrittlement of Hot-dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement

d) ASTM A153 Standard Specification for Zinc coating (Hot dip) on Iron & Steel Hardware.

e) ASTM A220 Specifications for Pearlitic Malleable Iron Castings

f) ASTM A384 Standard practice for safeguarding against warpage and distortion during Hot-dip Galvanizing of Steel Assemblies.

g) ASTM A239 Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).

h) ASTM A536 Specifications for Ductile Iron Casting.

i) ASTM A668 Specifications for Steel Forgings, Carbon and Alloy, for general industrial use.

j) ASTM C151 Test Method for Autoclave Expansion of Portland Cement.

k) ASTM C29.1 American National Standard Test Methods for Electrical Power Insulators.

l) ASTM C29.2 American National Standard for Wet Process Porcelain and toughened Glass Insulators.

m) IEC 575 Thermal mechanical performance test and mechanical performance test on string insulator units.

n) IEC 61284 Overhead Lines – Requirements and Tests for fittings.

o) BS 3288 Insulators and Conductor fittings for overhead power lines Part I. Performance and General Requirements.

p) IEC 61467 Insulators for overhead lines – Insulator strings and sets for lines with a normal voltage greater than 1000V-AC power arc tests.

q) IEC 60437 Radio Interference Test on High Voltage Insulators.

r) IEC 61211 Insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1 000 V - Impulse puncture testing in air.

s) IEC 305 Characteristics of insulator units of cap and pin type

t)	IEC 372	Locking Devices for Ball and Socket Couplings of String Insulator Units – Dimensions and Tests
u)	IEC 471	Dimensions of clevis and tongue of string insulator units
v)	IEC 60507	Artificial pollution tests on high-voltage insulators to be used on a.c. systems
w)	IEC 60060	High Voltage Test Techniques
x)	IEC 60120	Dimension of ball and socket coupling of String Insulator Units
y)	IEC 60383	Insulators for overhead lines with a nominal voltage above 1000V
z)	IEC 60672	Ceramic and glass insulating materials
aa)	CISPR 16-1	Specification for radio disturbance and immunity measuring apparatus and measuring methods – Part I: Radio disturbance and immunity measuring apparatus
bb)	CISPR 18-2	Radio interference characteristics of power lines and high-voltage equipment – Part 2: Method of measurement and procedure for determining limits
cc)		Other relevant ANSI, ASTM and IEC standards.

1.1.3.4 Accessories and Dampers

a)	ANSI C119.4	Electric Connectors - Connectors for Use Between Aluminum-to-Aluminum or Aluminum-to-Copper Conductors Designed for Normal Operation at or Below 93 °C and Copper-to-Copper Conductors
b)	ANSI/NEMA CC 1	Electric Power Connection for Substations
c)	ASTM A153	Standard Specification for Zinc coating (Hot Dip) on Iron and Steel Hardware
d)	ASTM A164	Standard Specification for Electrodeposited Coatings of Zinc on Steel.
e)	ASTM A239	Standard Method of Test for Locating the Thinnest Spot in Zinc (Galvanized) Coating on Iron or Steel Articles by the Preece Test (Copper Sulphate Dip).
f)	ASTM B580	Standard Specification for Anodic Oxide Coatings on Aluminum
g)	ASTM D1149	Standard Test Method for Rubber Deterioration - Surface Ozone Cracking in a Chamber
h)	ANSI B.1.1	"Unified Screw Threads" class 2A
i)	U.S Military Specifications MIL A-8025 C.	
j)	IEEE Paper No. 31 TP 65-156	Recommended Method of IEEE Task Force on Conductor Vibration

k)	IEEE Paper T74 061.8	Spacer Damper Performance – A function of In-Span Positioning
l)	IEEE Paper 31 TP 65-707	An Investigation of the Forces of Bundle Conductor Spacers under Fault Conditions
m)	CISPR 18-1 (Part 1)	Radio interference characteristics of overhead power lines and high voltage equipment
n)	CISPR 18-2 (Part 2)	Methods of measurement and procedure for determining limits.
o)	CISPR 18-3 (Part 3):	Code of practice for minimizing the generation of radio noise.
p)	IEC 61284	Overhead Lines – Requirements and Tests for fittings
q)	BS 3288	Insulators and Conductor fittings for overhead power lines Part I. Performance and General Requirements
r)	IEC 61897	Overhead Lines – Requirements and Tests for stockbridge type Aeolian vibration dampers
s)	IEC 61854	Overhead Lines – Requirements and Tests for spacers
t)	IEEE 1368-2006	IEEE Guide for Aeolian Vibration Field Measurement of Overhead Conductors
u)	Other relevant IEEE, IEC and ASTM Standard	

1.1.4 STANDARDS OTHER THAN THOSE SPECIFIED

Where requirements for material or equivalent are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. Other standards, including standard of other countries, will be accepted provided the requirements thereof, in the opinion of the Engineer, are at least equal to the requirements of the standard specified. The manufacturer may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required in this respect and shall submit written proof that proposed standard is equivalent in all significant respects to the standard specified. All submission must be made in the English language.

1.1.5 CLEANING AND GALVANIZING

All fabricated structural steel material and ferrous components shall be cleaned of rust, loose scale, dirt, oil, grease and other foreign substances, after the shop work has been completed. Unless otherwise specified or directed, all material, including bolts, nuts and washers shall be hot-dip galvanized, in accordance with the relevant ASTM

Specifications, after all shop work is completed except that nuts shall be re-tapped after galvanizing, and threads of nuts left bare.

All structural steel shapes shall be galvanized in accordance with ASTM A123. **The purity of Zinc used for galvanization of all ferrous articles, components and items shall be 99.995%.**

The coating shall be clean, smooth and free from defects. Bare spots, loosely attached spelter, unevenness of coating, and globules which may be broken in handling, will be cause for rejection by the Inspector.

If more than 5% of the galvanized material is rejected, galvanizing shall be stopped and the process altered so that satisfactory work is produced.

During galvanizing, the Inspector will carry out such tests on the coating and analysis of the spelter as he may consider necessary.

The Preece Test will also be included in these tests which will be carried out in accordance with ASTM Specification A239 latest edition.

All tower material shall, prior to shipping, be dipped in a suitable solution such as Sodium Bi Chromate to protect the galvanizing from "white rust" corrosion during transit. Full details of the treatment proposed shall be submitted to the Engineer for Approval. The effectiveness of the treatment shall be verified in accordance with ASTM B201.

All fabricated structural steel and plates that have been warped by the galvanizing process shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. If in the opinion of the Engineer, the material has been harmfully warped or bent in the process of fabrication or galvanizing, such defects will be cause for rejection.

Material on which galvanizing has been damaged shall be redipped. Any member on which the galvanized coating becomes damaged after having been dipped twice shall be rejected.

1.1.6 GALVANIZING OF NUT, BOLTS AND WASHERS

The galvanizing of nut bolts and washers shall be in accordance with ASTM A153. Bolts shall be galvanized in such a manner that the Zinc in the threads will not interfere with the application of the nut. Re-threading of bolt threads after galvanizing will not be permitted.

1.1.7 INSPECTION

All work covered by this specification, and the inspection thereof by the Supplier, shall be subject to surveillance and/or further inspection by the Engineer. The Supplier's inspector shall include, but not necessarily limit his duties to the following:

A. Material

The Supplier shall:

(i) Work only to those specifications provided herein and/or as specified by the Engineer.

(ii) Inspect the following materials for both quality and dimensions.
   a) Structural steel
   b) Sheet steel
   c) Nut and bolts
   d) Washers and fillers
   e) OPGW along with associated equipment and hardware
   f) Insulators, Hardware & Grounding Material
   g) Conductor Accessories
   h) Dampers for Conductor and OPGW etc.

(iii) Check and provide to the Engineer certified copies of the mill sheets covering the total quantity of the above applicable material.

B. Fabrication & Manufacturing Process

The Supplier shall:

(i) Work only to drawings and specifications approved by the Engineer.

(ii) Be responsible for ascertaining that all fabrication is carried out in compliance with the following:
   a) Exact shop drawing dimensions and notes
   b) The appropriate specifications
   c) Good shop practice
   d) Bending according to Clause 2.2.6 for tower steel herein
   e) Member markings, corresponding to those shown on the detail drawings, are clearly stamped on each individual member.
   f) Galvanizing in accordance with the ASTM standards.

(iii) Inspect the fabrication for all the foregoing items, (a) to (d) of A(ii) before galvanizing, and check that no further fabrication is carried out after galvanizing where dissimilar metals are used, suitable precautions shall be taken at the metal interface to prevent electrolytic corrosion.

(iv) Note that Casting of ferrous materials is not permitted, except for components not subject to stress.

(v) All ferrous components which have been cold formed & forged shall be normalized or otherwise heat treated to relieve stresses before galvanizing, if applicable.

(vi) Threads may be either cut or rolled except that the threads of ferrous bolts which are to be installed with a given torque value shall be rolled after galvanizing.

(vii) Necessary precautions shall be taken to prevent embrittlement of ferrous components, as specified in ASTM A143 & A384.

Periodically check the galvanizing against the appropriate specification requirements, which include testing of the galvanizing bond by the use of the Chisel-faced hammer.

C. Note and have corrected such items as:

1. Quality of materials not complying with specifications;
2. Incorrect quantities;
3. Incorrect dimensions and sizes;
4. Missing components and holes;
5. Substitution of unapproved material;
6. Incorrect location of bolt holes;
7. Burrs on punched holes;
8. Conically punched holes due to poor dies;
9. Under-sized members;
10. Members not bent or incorrectly bent; and
11. Left and Right of members not correctly bent or punched.

D. Electrical Requirements

1. The corona extinction voltage shall not be less than 346 kV line to ground.

2. All energized hardware assemblies shall be corona free at this voltage.

3. All energized hardware shall be designed and constructed so that the potential difference between the conductors and any part of energized hardware will not exceed 300 V.

4. If the Manufacturer cannot show, to the satisfaction of the Engineer, that the materials have been previously subjected to corona testing to the levels specified, then the Manufacturer shall submit to the Engineer a proposal for corona testing. Following the Engineer’s approval of the Manufacturer's proposed test program, the Manufacturer shall carry out these tests and if required shall modify his design so that the requirements are all met at no expense to the Purchaser.

E. Quality Control

1. The Manufacturer shall ensure that an adequate system of marking and/or coding of production lots for components are maintained. Once a size of production lot for a component is established, the size of that production lot shall remain constant until the work on the contract is completed.

2. Standards to be checked, in the Manufacturer's Quality Control Plan shall include, but not be limited to the following:
   a) Dimensional tolerances;
   b) Quality, surface finish and ease of fit;
   c) Assembly procedures and requirements; and
   d) Production tests.

3. The schedule of production tests may be amended or changed by the Engineer at any time prior to the completion of this Contract.

F. Testing

1. It shall be the Manufacturer's responsibility to provide and perform all the inspection and testing necessary to ensure compliance with these specifications.

2. Quality surveillance will be provided by the Engineer or his authorized representative (hereinafter called "the Inspector").

3. The Inspector shall have free access to those parts of the Manufacturer's Services that concern the manufacturing of this material at all times while work on this Contract is being performed. The Manufacturer shall provide the Inspector, with all reasonable facilities to enable him to be satisfied that the material is being furnished in accordance with these specifications.

4. The Inspector shall have the authority to ask any additional testing or inspection he considers necessary in order to ensure compliance with the specifications and drawings.

5. The Inspector's decision for acceptance or rejection of any work shall be final.

G. Reports

Inspector shall submit to the Engineer four (4) copies of his inspection report, covering the following:

1. Progress of fabrication;
2. Progress of fabrication and galvanizing for steel;
3. Any change in completion dates;
4. Substitution of material;
5. Detailed remarks on any technical difficulties; and
6. Detailed remarks on any material rejected before fabrication, after fabrication and after galvanizing.

Whether the Purchaser and Engineer are present or not, the Supplier shall carry out all tests as specified in the relevant standard and he shall supply the Engineer with three (3) copies of all test data obtained.

2. GALVANIZED LATTICED STEEL TOWERS

This section of Technical Provisions specifies the minimum technical requirements for design, engineering, manufacture, inspection, testing and performance of Galvanized Transmission Line Latticed Steel Towers.

2.1 TYPES OF TOWERS

Double Circuit Suspension Tower Type "DS1"
Double circuit suspension tower type "DS1" will be utilized for line angles up to 2°. The tower consists of basic body, body extension of 6.0 m and leg extensions of 2.0 m, 4.0 m, 6.0 m & 8.0 m. Maximum wind and weight spans at 0 line angle will be 380 m & 450 m respectively.

Double Circuit Light Angle Tower Type "DA1"
Double circuit strain tower type "DA1" will be utilized for line angles up to 20°. The tower consists of basic body, body extension of 6.0 m and leg extensions of 2.0 m, 4.0 m, 6.0 m & 8.0 m. Maximum wind and weight spans at 20°line angle will be 380m & 730m respectively

Double Circuit Dead End/Heavy Angle/Terminal Tower Type "DD1"
Double circuit strain tower type "DD1" will be used for line angles up to 60° and as dead-end/terminal tower up to 20° angle of entry. The tower consists of basic body, 6.0 m body extension and leg extensions of 2.0 m, 4.0 m, 6.0 m & 8.0 m. Maximum wind and weight span limits will be 380m & 730m respectively for line angles up to 60° and wind span 300m and weight span 400m for 20° in terminal condition.

Single Circuit Dead End/Heavy Angle/Terminal Tower Type "DGM"
Single circuit strain tower type "DGM" will be used for line angles up to 60° and as dead-end/terminal tower up to 20° angle of entry. The tower consists of basic body, 9.1m body extension and leg extensions of 1.5 m & 4.5 m. Maximum wind and weight span limits will be 366m & 610m respectively for line angles up to 60°.

2.1.1 DRAWINGS

The manufacturer shall be required to prepare detail fabrication and erection drawings including individual bill of quantity and detail bill of material of tower types "DS1", "DA1", "DD1", & "DGM" based on detail drawings attached in Volume-III of the Bidding Documents.

If any changes are made to suit conditions in the country of origin for good and sufficient reasons, the burden of proof shall be on the Supplier to show that such change or changes will result in completed tower/towers of equal or increased capability.

No work shall be commenced prior to written approval of the Engineer.

2.2 DETAILED REQUIREMENTS

2.2.1 CONNECTION DETAILS

The connection details for insulator hardware and OPGW hardware shall be similar to the typical details shown on the drawings for each tower type. Holes for moving parts shall be drilled and chamfered unless otherwise specified. Such holes shall have adequate bearing area and in addition to the normal edge distance shall have an extra 6.5 mm edge distance to provide for wear.

Details of holes for danger signs, number signs, phase plates, aerial markers, grounding and anti-climbing devices shall be in accordance with Specification Drawings.

2.2.2 STRUCTURAL STEEL

All rolled steel sections and plates shall be supplied in accordance with latest edition of ASTM A572 Grade 60 High Strength Low-Alloy Columbium-Vanadium Steel of Structural quality or equivalent, EN10025 S355J2 or equivalent, ASTM-A36 or equivalent. In addition to requirements specified hereinabove and in the relevant standards, the offered steel shall withstand the following bend test requirements. However, procedure of bend test requirement shall be followed as per ASTM A370.

Type of Steel	Thickness of Material	Ratio of bend dia to thickness of specimen at 180º
Mild Steel	For all thickness	1.5
High Tensile Steel	Up to 25 mm	1.5
Grade 50 & 60	Over 25 mm	2.0

For the fabrication of the towers, the Supplier may propose the use of any steel, provided that the proposed steel have characteristics and properties equal to or better than those listed for steel mentioned in the specifications. However, acceptance of any proposed alternative steel will be at the discretion of the Engineer.

2.2.3 NUTS, BOLTS AND WASHERS

For all types of towers, all connections shall be secured by bolts, nuts, plain and spring washers. Hexagonal head bolts and hexagonal nuts shall be used. Only one plain washer and one spring washer per bolt shall be used.

Bolts shall be designed for only bearing and shear and the shank of all bolts except U-bolts shall extend completely through all connected members. When in position bolts shall project through the corresponding nuts neither less than 2 thread lengths nor greater than 10 mm. Members shall not bear on thread. Washers shall be used under all nuts. Bolts shall be free from fins, scale or other defects and the head shall be concentric and square with the shank. The diameter of the shank shall be full nominal size of the bolts. The ends shall be sharp and clean and of the proper contour.

All U-bolts shall be threaded for a sufficient length to take two standard nuts plus member and washer thicknesses.

Step bolts shall be provided as shown in the drawings. Step bolts shall be provided on two legs of the tower diagonal to each other. Each step bolt shall be supplied with three (03) nuts or as per the specification drawings attached in Vol-3.

Nuts shall be of sufficient height to develop the full strength of the bolt. Threads must not be torn or ragged and shall be of proper contour. The nuts shall fit the bolts after they have been galvanized so that they can be started and threaded by hand for the full length of the bolt thread.

The fit of the nut on to the bolt shall be such that no rocking of the nut will occur.

Nut and bolt of the same size shall be interchangeable. The bolt related dimensions for fabrication can be referred from DIN 7990 and nut according to DIN 555/ISO4034 The length of bolts shall be calculated to accommodate the thickness of one plain and one spring washer.

Material of bolts and nuts shall conform to ASTM A325 and/or ISO 898 standards.

The dimensions and material of plain washers (circular) shall be according to ASTM F436.

The dimensions and material of spring lock washers shall be according to DIN127 and 128.

At least 5% surplus of bolts, nuts and washers shall be supplied to cope with losses and future maintenance.

The fabricated material shall not have physical properties inferior to those specified.

Bolt hole diameter shall not exceed the nominal diameter of the fastener plus 1.5 mm.

Ring fillers for the towers to be supplied in accordance with the dimensions given in the drawing provided in Volume-III. The material of ring filler shall conform to the properties of mild steel as per ASTM A36.

The minimum edge distances of bolts measured from the center of the bolt hole to the end of the member shall be as follows:

a) For Compression Members: One and one-half bolt diameters.

b) For Tension Members: In an end connection of not more than three bolts the end distance shall not be less than that given in (a) above or the following quantity, whichever is greater.

Minimum Bolt Diameter	Minimum Edge Distance	
	Rolled Edge	Sheared & Mechanical Guided
16 mm	19 mm	24 mm
20 mm	26 mm	30 mm
24 mm	30 mm	38 mm

c) For gusset plates one and one-half bolt diameter.

d) Minimum spacing of bolts shall be as follows:

Bolt Diameter	Minimum Bolt Spacing
16 mm	35 mm
20 mm	45 mm
24 mm	55 mm

2.2.4 BIRD GUARD

To prevent birds perching immediately above the suspension/jumper insulator strings and fouling the same with dropping, suitable bird guards shall be provided on all types of towers. Saw type bird guard shall be **designed** and provided on all the members/redundant members provided on top and bottom plan of cross arm/girder/boom/beam of suspension. Suitable provision of cleat / plate to be provided on all Suspension towers facilitating installation of bird guard after stringing.

2.2.5 WORKMANSHIP

The workmanship and finish throughout shall be of a quality equal to the best that is known to the art at the present time for this class of work. All work shall be carefully and accurately performed.

Members shall be cut to jig and holes shall be drilled or punched to jig. All holes shall be cylindrical and perpendicular to the member. Where necessary to avoid distortion of holes close to the points of bends, the holes shall be made after bending.

Fabricated steel work shall be in accordance with the drawings, and drilling, punching, cutting and bending shall be carefully and accurately performed to prevent any possibility of irregularities occurring which might introduce difficulty in the erection of towers or result in straining or distortion of the parts thereof.

2.2.6 BENDING

Tower members which are cold bent shall be normalized before galvanizing. Hot bending is preferred. The heating shall be done in an oven, so that the member is uniformly heated to a distance of approximately 150 mm either side of the bend point. Proper heat-treating procedures shall be used in order to preserve the original physical properties of the metal. Bending of thick members shall be done in a hydraulic press with a suitable die to prevent buckling of an unrestrained leg. This process shall not be done under quick impact but through a slow-moving press.

Cutting the outstanding legs of angles or flanges of channels and then welding at the bend point shall not be permitted.

All bends shall be finished free from waves and folds. The practice of cutting out sections and welding to facilitate the bending of bent members will not be permitted.

2.2.7 PUNCHING & DRILLING

Punching and drilling shall be done by methods designed to ensure accuracy. The center of any hole shall not vary more than 1.5 mm from its position neither shall the center-to-center distance of end holes in a group of holes vary by more than 1.5 mm. Plugging and welding of drilled holes shall not be permitted

Drills, punches and dies shall be sharp and true, and holes shall be round, true to size, and free from ragged edges and burrs. Punching shall be done before galvanizing in such a manner as to produce cylindrical holes normal to the plane of the material. The holes shall not be out of round, or taper from the top to bottom in excess of 1.5 mm. The punchers and dies shall be maintained in such condition as to produce clean holes, free from burrs, folds depressed or upset edges.

Bolt holes shall have diameter 1.5 mm larger than the nominal diameter of the bolt.

It is preferable to have fabrication, punching and drilling carried out by means of a modern computer program technique.

All holes in material over 19mm mm in thickness shall either be drilled or sub-drilled and reamed.

When a material is bent, all holes near the bend shall be punched after the bend is made.

For high tensile steel (yield point equal or greater than 35 kg/mm^2) holes shall be directly drilled at the definitive diameter or punched and reamed out. The difference between the punched and reamed diameter shall be not be more than 4mm.

The die for all sub-punched holes, and the drill for sub-drilled holes, shall be at least 1.5 mm smaller than the diameter of the bolt. Drifting to enlarge holes shall not be permitted.

2.2.8 WELDING

Welding of structure members, filling or plugging of defective parts and mispunched holes shall not be permitted in tower fabrication. When holes are mispunched so that the net section of a member is decreased, the member shall be discarded. However, if welding cannot be avoided and is required in certain structure components, such as for rigging/attachment plates, prior written approval shall be obtained. In such cases welding procedures shall comply with ANSI/AWS D1.1M standards. Special care shall be taken regarding seal welding to ensure proper galvanizing and to avoid acid “bleeding” at pockets in structural assemblies.

2.2.9 GENERAL REQUIREMENTS FOR FABRICATION

The towers shall be fabricated having members’ sizes according to the approved drawings.

Shearing and cutting shall be performed carefully and all portions, which will be exposed to view after completion, shall be neatly finished. All burrs shall be removed. Ends shall be squared within 1.5 degrees.

Structural materials shall be straight before being laid out or worked in any manner. Straightening will not be permitted.

All bending shall be done in such a manner that the full section and member length will be maintained within 5 percent reduction and that the physical properties of the material will not be impaired. Bending shall be made across the grain structure of the material.

All bends shall be finished free from waves and folds. The practice of cutting out sections and welding to facilitate the bending of bent members will not be permitted.

2.2.10 SUBSTITUTION

The towers shall be fabricated having members' sizes according to the approved drawings. However, substitution may be allowed for member sizes not available. Substitution of angel sections having equal or higher thickness and flange size than the specified thickness and flange size will be acceptable.

The permissible variation from dimensions for structural size steel shapes shall not exceed the prescribed limits in ASTM A6. Permissible variation from cross sectional area and weight of each structural size shape shall be ±2.5% from the theoretical or specified amounts. Latest version of Chinese Standard GB/T-706 shall be applicable for calculation of reference cross-sectional area and weights of equal/unequal angle sections.

2.2.11 ALLOWANCE FOR GALVANIZING

Allowance shall be made in gauge dimensions for the thickness of galvanizing and the possible formation of spelter fillets inside the angles so as to allow adequate erection clearance after galvanizing.

2.2.12 BLOCKING

Blocking of outer legs of angles will not be permitted.

2.2.13 ANGLE LAPS

Where angles are lap spliced, the heel of the inside angle shall be chamfered to clear the fillet of the outside angle.

2.2.14 MARKING

Each structure member shall have its tower name along with mark number, contract No., and manufacturer's name/insignia conforming to the piece-mark on the erection drawings stamped with a metal die. For galvanized materials, these marks shall be stamped prior to galvanizing. Marks shall be a minimum of 12 mm high. The marks

shall be placed, preferably, near one end in the same relative position on each member, so as to be easily seen after assembly of structure.

High strength steel members (Grade EN10025, S355J2 or equivalent and ASTM A572 Gr.60 or equivalent) shall include a suffix "H" and "E" or "HH" respectively, on the piece-mark, whereas mild steel members shall not have any suffix.

2.2.15 TOLERANCES

Ease of assembling the structure in the field is of utmost importance. The structure shall be so manufactured that all members carrying the same mark shall be interchangeable when assembled. The structure shall fit without undue pressing and no reaming or drifting of holes shall be required. When erected, the structures shall not deviate from the vertical by more than 1/300 ratio.

The Manufacturer shall be responsible for the correct fitting of all parts and shall replace free of cost any defective materials discovered during erection and shall pay all costs of the correction in the field of any errors not previously discovered.

The permissible variation from dimensions for structural size steel shapes shall not exceed the prescribed limits in ASTM A6.

2.2.16 TOWER ACCESSORIES

(i) Sign Plates and Aerial Markers:

All the plates i.e. danger sign, number & phase plates and aerial markers shall be baked ceramic surfaces on high grade steel base plates of minimum thickness of 1.5 mm except aerial marker plate which shall be of 3mm thickness. Fabrication details and dimensions of the plates are shown on the drawing attached in Volume-III.

The plates shall be painted with ceramic paint on both sides and shall be thoroughly cleaned before painting and the ceramic paint shall completely cover the front and back of the plates and also the edges of plates and the interior edges of the attachment holes. The ceramic paint shall be of even thickness, reasonably free from cracks, patches, pin holes, blisters and shall have a uniform gloss. The ceramic paint around the holes shall be protected by means of fiber washers.

Three coats of ceramic paint shall be applied on the danger sign and number plates. The first coating of black ceramic paint shall be applied on both sides of the plates. The other two coats of white ceramic paint shall be applied on the front side of the danger & number plates and yellow on aerial marker plates.

In case of phase plates, three coats of ceramic paint shall be applied. The first coat of black ceramic paint shall be applied on both sides. The other two coats of red, yellow and blue color shall be applied as specified on both side of the plate.

Nos. of bolts, nuts, washers and fixtures where required shall be supplied with each plate as shown in the drawings. Bolts, nuts and washers to be supplied with the fixture shall be galvanized in accordance with ASTM A153.

(ii) Anti-climbing Devices:

Material, dimensions and testing of the barbed wire shall be in accordance with ASTM A121.

The size and characteristics of the zinc coated barbed wire shall be as per design number 12-2-4-14R, Type Z with Class 3 coating.

The material of structural steel of anti-climbing devices shall be maximum of mild steel as per ASTM A36 and galvanization according to ASTM A153.

2.2.17 DOCUMENTS & DRAWINGS

The Manufacturer will be supplied the drawings indicating various dimensions, angle sizes used, sizes of bolts used, type of steel and various standards/process to be followed for fabrication and galvanizing of the structure.

After approval of contract, the Manufacturer shall submit for approval, the following drawings:

a) Shop Details Drawings:
The detailed drawings shall show shop details including dimensions, shearing, punching, bevel cutting, bending and identification mark and weight for each member.

b) Erection Drawings:
Erection drawings shall show the complete assembly of the structure indicating clearly the positioning of the members. Each member shall be piece-marked and the number and lengths of bolts shall be given for each connection. Shop details may be shown either by assembled sections (in place) or piece by piece (knocked down).

c) Footing Installation Drawings:
Footing erection drawings showing each member with its identification mark, number and size of connection bolts and all dimensions required for the proper setting and positioning of stub angle footings with relation to the center of the structure.

d) Bills of Material:
Bills of material for each tower shall show the quantity, type, size, length; weight and assembly mark for each member, including bolts, washers, plates and all fittings complete for each structure.

e) Outline Drawing:
Manufacturer shall prepare 3-D and 2-D single line diagram from the detailed drawings which shall show the complete information like dimensions and member, angle sizes, conductor & OPGW hardware attachment points.

f) Drawings of Tower Accessories
Drawings of tower accessories as per clause 2.2.16 shall be submitted.

2.3 TESTS FOR TOWER STEEL AND ASSOCIATED HARDWARE

2.3.1 MANUFACTURER'S TESTS

The Manufacturer shall select two samples from each heat to carry out the following tests to satisfy him that the products comply with the specifications.

a. For Sections and Plates
   1. Chemical composition (Ladle Analysis)
   2. Tensile Tests
   3. Bend Tests

b. For Nuts and Bolts
   1. Proof Load test
   2. Ultimate Tensile Strength test
   3. Ultimate tensile strength test under eccentric load
   4. Cold bend test
   5. Hardness test
   6. Galvanizing test

c. For Washers and Ring Fillers
   1. Hardness test
   2. Galvanizing test

Manufacturer shall maintain a record of tests carried out by him for examination by Inspector.

2.3.2 PROTOTYPE TOWER ASSEMBLY TESTING

The manufacturer will fabricate the material for prototype assemble, to be witnessed by T/L Design Engineers at manufacturer's works for local supplier and online for foreign supplier, to verify that tower components fit properly. The check assembly shall be preferably in vertical position. In case of assembly in horizontal position, the complete tower assembled along with body/leg extensions shall be adequately supported to prevent distortion and overstressing of members to ensure proper fit and shall be accomplished without extraordinary effort to align bolt holes or to force pieces into position. For the check assembly, bolts and nuts shall be not more than finger tight. The members and nuts, bolts, lock nuts, washers, fillers etc. used in prototype assembly shall be of the same grade & size/dimensions specified in the approved drawings and to be supplied against the respective contract/purchase order.

During prototype assembly, fitting attachment points, joint connections of different sections such as Body & Leg Extensions with basic body, grip length of nuts & bolts, hole sizes, fillers and dimensions of the members will be checked and Details will be recorded in the prototype assembly report. If there is any anomaly, the same will be rectified and final drawings will be prepared and submitted to NTDC for review and approval for mass production.

Following should be kept in view during prototype tower assembly:

(a) Check carefully each member while assembling the prototype to revise and amend the detailed drawings according to the correct solution;

(b) For each member, the length, position of holes and interface with other members shall be checked accurately for proper fitness;

(c) Quantity of each member and bolts shall be carefully checked from the bill of materials when assembling the prototype;

(d) On the assembled tower eventual modifications shall be examined and performed, if necessary, without modifying the functionality of the structure; and

(e) Drawings and bill of materials, sizes of bolts, fillers etc. shall be put up-to-date accordingly, in all details before starting mass production.

All changes/modifications incorporated in the drawings shall be brought to the notice of Engineer along with corrected final copies of the drawings for approval before starting mass production. The Manufacturer shall also submit details of all the changes/modifications carried out.

2.3.3 MATERIAL ACCEPTANCE TESTS

The following governs the acceptance tests:

2.3.3.1 Acceptance Tests for Sections and Plates

For Sections and Plates, the following acceptance tests shall be carried out:

(i) Visual examination
(ii) Verification of dimensions
(iii) Chemical composition
(iv) Tensile tests
(v) Bend tests
(vi) Impact tests
(vii) Galvanizing tests
(viii) Prototype Tower Assembly

Supplier shall render all necessary assistance to Inspector in carrying out the above tests.

(i) Visual Examination:
Samples for the tests shall be visually examined but not limited for material type, shape, galvanizing and general finish with respect to applicable specifications and drawings.

(ii) Verification of weights and dimensions:
The cross sectional area and weight of each structural size shape shall not vary more than 2.5% from the theoretical or specified amounts.
The permissible variation from dimensions for structural size steel shapes shall not exceed the prescribed limits in ASTM A6.

Weight of each tower type in the offered Lot	Minimum nos. of samples to be taken from each type of tower
≤600 tons	20
>600tons and ≤1000tons	25
>1000tons and ≤1400tons	35
>1400tons	50

(iii) Chemical Composition:

To indicate adequately, the chemical composition of a heat or a lot, the minimum number of samples of each grade of steel selected to represent the heat shall be as follows:

	No. of Samples
500 tons or more	5
500 tons or less	3

If a sample fails to meet the requirement, the material of the respective steel grade in the lot shall be rejected.

(iv&v) Tensile and Bend Tests:

Sampling plan for tension and bend tests shall be made for each grade of steel as per following Table from the offered lot.

Weight of finished shape of angle section/plate of each steel grade in the offered Lot	Tension Test	Bend Test
≤600 tons	06	03
>600 and ≤1000 tons	12	06
>1000 tons and ≤1400 tons	16	08
>1400 tons	24	12

If a test sample fails to meet the specified requirements, then four more samples shall be selected for tension and bend tests from the same grade of steel. If a test sample fails in the retest, \then the respective steel grade of the offered lot shall be rejected.

(vi) Impact Tests:

Sampling and testing shall be as per Euro norm EN 10025. However, the impact tests shall be carried out on angle sections separately for each grade of steel having thickness ≥ 10mm.

(vii) Galvanizing Tests:

To check that whether the galvanization is according to the specified standard or not, following tests shall be carried out on all ferrous parts complying with the following specified requirements.

(a) Weight of zinc coating
(b) Coating thickness measurement by meter
(c) Uniformity of zinc coating

The uniformity of zinc coating shall be determined by Preece test as per ASTM A239. The minimum no. of dips for each test sample shall be six (06) while time for each dip shall be at least one (01) minute.

(d) Adherence of zinc coating
Sampling for determination of compliance to the tests specified shall be performed in accordance with relevant ASTM Specification and shall be taken from each lot. The lot shall consist of a quantity as specified in the relevant specifications.

(e) Embrittlement test
Sampling for determination of compliance to the tests specified shall be performed in accordance with relevant ASTM Specification and shall be taken from each lot. The lot shall consist of a quantity as specified in the relevant specifications.

(viii) Prototype Assembly Test:
Test to be carried out as per requirements specified in clause 2.3.2 herein above.

2.3.3.2 Acceptance Tests for Nuts and Bolts

For Nuts and Bolts, the following acceptance tests shall be carried out:

(i) Visual inspection
(ii) Verifications of dimensions
(iii) Mechanical Tests
  (a) Proof load test
  (b) Ultimate tensile strength test
(iv) Galvanizing tests
  (a) Coating thickness measurement by meter
  (b) Uniformity of zinc coating
  (c) Adherence of zinc coating
  (d) Weight of zinc coating
(v) Hardness test (Alternatively, Ultimate Tensile Strength for bolts less than M16x35).

Supplier shall render all necessary assistance to Inspector in carrying out above tests.

(i) Visual Inspection:
The inspection shall cover finish defects such as rough galvanizing, bare spots, fins and any other defects not permissible under the specifications.

(ii) Verification of Dimensions:
The dimensions of the nuts and bolts shall be checked according to the specified standard hereinabove.

(iii) Mechanical Tests:
  (a) Proof Load Test
  (b) Ultimate Tensile Strength Test.
These tests shall be carried out on the selected samples as per the test procedure defined in the relevant specifications.

(iv) Galvanizing:
The galvanizing tests shall be carried out as per relevant ASTM standards.

(v) Hardness Test:
These tests shall be carried out on the selected samples of the bolts which shall have size less than M16x35 and shall not undergo for tensile tests.

Sampling, Acceptance and Rejection:

Lot offered for inspection should be according to the size of bolts i.e. M16, M20 & M24. Each lot shall be divided into the batches of 10,000 units (1 unit = 1 nut & bolt). Five units shall be selected from a batch of 10,000 units or lesser in quantity and shall be tested for the above tests in the order as defined herein above except the galvanizing tests for which sampling shall be as per ASTM A153. If any unit selected from a batch fails (even if only bolt or nut) to meet the requirements of specified tests then five more units shall be selected at random from the same batch for retesting. If during retesting, the entire units meet the specified requirements then the batch shall be accepted and, if any unit does not meet the specified requirement during retesting, the lot of that size shall be rejected.

2.3.3.3 Acceptance Tests for Plain Washers, Spring Lock Washers and Ring Fillers

The following acceptance tests on plain washers, spring lock washers and ring fillers shall be carried out:

(i) Verifications of dimensions	Tests shall be carried out as per DIN127 & 128 on spring lock washers, plain washers as per ASTM F436 and for ring fillers as per drawing
(ii) Visual inspection	
(iii) Galvanizing tests	As per ASTM A153
(iv) Hardness test	Tests as per DIN 127 & 128 on spring lock washers, ASTM F436 for plain washers and as per ASTM A36 on ring fillers.
(v) Twist test for spring lock washer	Tests shall be carried out as per
(vi) Spring force test	DIN267 on spring lock washers only

Supplier shall render all necessary assistance to Inspector in carrying out above tests.

Sampling, Acceptance and Rejection:

Lot offered for inspection should be according to the size of spring lock washers, plain washers and ring fillers i.e. M16, M20 & M24. Each lot shall be divided into batches of 10,000 units. Three units shall be selected from a batch of 10,000 units or lesser in quantity and shall be tested for the above tests in the order as defined herein above, except the galvanizing tests for which sampling shall be as per ASTM A153. Two samples each shall be selected from M16, M20 & M24 sizes for twist test for spring lock washer and spring force test from the lot having a quantity of less than 20,000 and four samples each from the lot having a quantity of more than 20,000. If any unit selected from a batch fails to meet the requirements of specified tests then five more

samples shall be selected at random from the same batch for retesting. If during retesting, the entire units meet the specified requirements then the batch shall be accepted and if any sample does not meet the specified requirements during retesting the lot of that size shall be rejected.

2.3.3.4 Acceptance Tests for Sign & Number Plates and Aerial Markers

Following acceptance tests for Sign & Number Plates and Aerial Markers shall be carried:

a. Visual examination

b. Verification of dimensions

c. Galvanizing test (on fixture and nuts & bolts only)

d. Resistance to thermal shock (vitreous enamel finish)

(i) Visual Examination:

Examination	Defects
a. Construction	Not of the shape given in relevant Drawing. Any crack on nut & bolt.
b. Material	Not of proper material.
c. Finish	Galvanizing of bolts, nuts, washers & fixture not proper, presence of black spots, blisters, flux, dress, un-coated areas or any other defects. Bolts & nuts, rusty. Threads marred. Plates not properly enameled or presence of cracks, patches, pin-holes, blisters or any other defect. Letters & numbers broken or not properly enameled.
d. Marking	Missing or in-complete or not as per drawing.

(ii) Verification of Dimensions:

Dimensions of the danger, number, aerial markers, phase plates and fixtures shall conform to those given in drawing nos. NTDC/DESIGN/17 with allowable tolerances as marked on the individual drawings. Any variation from the specified dimensions shall constitute a defect.

(iii) Galvanizing Test:

The galvanizing of the nuts, bolts, washers and fixtures shall be tested in accordance with ASTM Specifications.

(iv) Resistance to Thermal Shock:

This test shall be carried out by subjecting the test specimen to radiant heat so as to reach a steady temperature of 185-195°C in about ten minutes. The temperature

shall be measured by means of a surface pyrometer in contact with the top surface of the heated part of the specimen.

Remove the radiant heat and within 5 seconds quench the surface with 1000 ml of water at 15-20°C direct from an aspirator or other container through a 5 mm diameter tube, the end of the tube being 150 mm above the center of the heated portion of the test specimen. The flow rate of water shall be adjusted to 10 ml per second. It is convenient to mark the test area to ensure that the water is correctly applied. Dry the plate, replace in the same position under radiant heat source and repeat this procedure until six cycles have been completed.

After subjecting the test specimen to the above test, the vitreous enamel surface shall be considered to be resistant to thermal shock provided that the enamel shows no signs of flaking-off or crazing.

Sampling, Acceptance and Rejection:

Danger, number, phase plates, aerial markers and fixtures offered for acceptance shall be divided into lots containing up to 200 units in each lot. A sample of 12 units (3 each from danger, number, phase and aerial marker) shall be drawn at random from each lot. For thermal shock test two samples each shall be randomly selected from the offered lot.

The selected samples shall be subjected to the visual examination, verification of dimensions and galvanizing. If the number of defective units is two, the lot shall be accepted. If the number of defective units is more than two the lot shall be rejected. If the number of defective units is three, another sample of 12 units shall be selected at random and subjected to tests. If the number of defective units is again three or more then the lot shall be rejected and if the number of defective units is less than three then the lot shall be accepted.

2.3.3.5 Acceptance Test for Barbed Wire

The following acceptance tests for barbed wire shall be carried out:

a. Visual examination

b. Verification of dimensions

c. Galvanizing

d. Mechanical

These tests shall be carried out on the selected samples as per the test procedure defined in the relevant ASTM specification.

3. HARDWARE AASEMBLIES FOR CONDUCTOR AND OPGW

This section of Technical Provisions specifies the minimum technical requirements for design, engineering, manufacture, inspection, testing and performance of conductor and OPGW hardware to be used on 500kV double circuit quad bundle transmission lines.

3.1. GENERAL INFORMATION AND SCOPE:

3.1.1. GENERAL INFORMATION

NTDC is constantly expanding its network for reliability, efficiency, sustainability and in this connection, following interconnections have been planned:

i. "500 kV double circuit transmission line on quad bundled drake conductor from Sialkot Substation to Lahore North (Approx. 75 km)".
ii. "500 kV Double Circuit Transmission Line on Quad Bundled Drake Conductor for In/Out of the existing 500kV Multan-Sahiwal (Yousafwala) Single Circuit at Vehari Substation (Approx. 35 km).

Insulation requirements for both the transmission lines are as under:

3.1.1.1. Suspension Strings for Suspension Towers and Jumper Suspension Strings for Tension Towers

240kN M&E strength Non-Ceramic Composite Insulators shall be used in Suspension assemblies (V Single Strings) for Double circuit suspension tower 'DS1'.

120kN M&E strength Non-Ceramic Composite Insulators shall be used in Jumper Suspension assemblies (V Single Strings) for Double circuit tension towers 'DA1' & "DD1" and Single circuit tension tower 'DGM".

120kN M&E strength Non-Ceramic Composite Insulators shall be used in Jumper Suspension assemblies (I Single Strings) for Single circuit tension tower 'DGM".

Non-Ceramic Composite Insulators to be used in V-Strings and I-Strings shall have minimum leakage distance of 15805 mm and maximum length of 4930 mm.

3.1.1.2. Tension Strings for Tension Towers

29x4 Nos. 160kN Anti-Fog type Toughened Glass Disc Insulators shall be used in Dead End Assemblies (quad strings) for Double circuit tension towers 'DA1' & "DD1" and Single circuit tension tower 'DGM".

29x2 Nos. 160kN Anti-Fog type Toughened Glass Disc Insulators shall be used in Dead End Assemblies (double strings) at terminal tower "DD1" and gantry of the grid station.

Route alignment for the both the lines in .kmz file format is being provided with the bidding documents. The transmission lines will be constructed using ACSR Drake Conductor in quad bundle configuration using NTDC's existing tower type "DS1",

"DA1", "DD1" and "DGM". Tower outline drawings including connection details for hardware assemblies are attached with the bidding documents.

3.1.2. Electrical Parameters of Transmission System

i.	System Voltage	500kV
ii.	Maximum Voltage	550kV
iii.	BIL (Max)	1550kVp
iv.	BSL (Max)	1175kVp
v.	Power Frequency Withstand Voltage (wet)	680kVrms
vi.	Min. Corona Extinction Voltage at 50Hz under Dry Condition	346kV_{l-g}
vi.	Maximum RIV at 0.5 MHz, dB	60 dB above 1µV
viii	Short Circuit Level for 1 second	50kA

3.1.3. SERVICE CONDITIONS

The Contractor shall be deemed to have inspected and examined the Site and its surroundings and information available in connection therewith including service conditions, pollution and metrological data. The Insulators and T/L hardware to be supplied against this specification shall be suitable for satisfactory continuous operation under prevalent site conditions. The insulator assemblies should stay corona free without requiring any extensive maintenance.

3.1.4. SCOPE OF WORK FOR INSULATOR HARDWARE ASSEMBLIES

The contractor will carry out its engineering and design insulator assemblies (hardware + insulators) that are suitable for the site service conditions. Then, the contractor will manufacture the material (complete insulator strings for ACSR Drake Conductor in quad bundle configuration including Toughened Glass/Non Ceramic Composite Insulators (whichever applicable). The scope includes, but is not limited to, design & engineering, manufacturing & testing, furnishing, insuring, marine transportation and delivering the material.

It will be responsibility of the contractor/supplier to ensure satisfactory continuous electrical and mechanical operation of complete insulator strings in service conditions specified in these specifications.

3.1.5. INTERCHANGEABILITY

The hardware for insulator strings with insulators together with ball & socket/tongue & clevis fittings shall be standard design, so that these hardware are inter-changeable with each other and suitable for use with insulators of any make conforming to relevant NTDC specifications and compatible with tower geometry and clearances.

3.2. GENERAL CONSIDERATIONS

The material offered shall be suitable for operation in pollution. It should be suitable to sustain the heavy atmospheric pollution without being affected by it and remaining free from corrosion.

Each hardware item shall be marked with manufacturer trade mark, strength and year of manufacture.
Indicative drawings of hardware assemblies to be supplied under the provisions of this section of Specifications are attached in Volume – III of the Bidding Documents.
In addition to the provisions of this specification, the hardware strings and all components should fully comply with the requirements of IEC 61284.
The purity of Zinc used for galvanization of all ferrous articles, components and items shall be 99.995%.
For any of the conductor assemblies, the minimum phase-ground strike distance shall not be less than 4.0 meters.

3.2.1. MATERIAL

Only new manufactured materials shall be used.
All aluminum material shall be manufactured from primary ingot.
In general, ferrous components fabricated by casting are not acceptable and forged components are preferred. Where a proposed part is cast, this shall be clearly identified on Contractor's drawings.
It is preferred that forming and bending is performed hot. Where cold forming and bending must be used, hardware component shall be stress relief heat treated after the product has assumed its final shape. Stress relief shall be done prior to galvanizing.
Embrittlement or loss of ductility due to stress concentration, strength hardening and quenching shall be avoided.

3.2.2. DESIGN DRAWINGS

Upon award of the Contract, the Supplier shall produce detailed assembly and individual component drawings along with isometric views. These drawings shall include:

a. All physical dimensions including dimensions of mating surface and tolerance,
b. Weights,
c. Dimensions and associated tolerances,
d. Short circuit/Power Arc and corona ratings,
e. Strength ratings (yield and failure)
f. Design tightening torques,
g. Types of material used,
h. Method of manufacturing,
i. Reference standard used,
j. Coupling type,
k. Location and size of rigging holes,
l. Drawing and revision number,
m. Project name,
n. Drawing scale.

No fabrication shall commence until detailed assembly and individual component drawings are reviewed and approved by the Engineer. Hardware assembly drawings are also required to be submitted with the Bid.

3.2.3. WELDING

Welds shall not be used in the design and manufacture of any component of Hardware Assembly, with the exception of grading rings/arcing horns in which case the approval of method of welding and reinforcement will be at the discretion of the Engineer.

3.3. CONDUCTOR & OPGW DATA

Characteristics	Conductor	OPGW
Type	ACSR	Aluminum-Clad Steel
	code word “DRAKE”	OPGW
Size	795 KCM	-
Stranding Al. St.	 26x4.4mm 7x3.45 mm	-
Outside Diameter	28.14 mm	≤12.5mm
Ultimate Tensile Strength	14,174 kg	≥ 7500 kg
Nominal Weight	1,628 kg/km	≤465 kg/km
Direction of Outer Layer	Right Hand	Left Hand

3.4. CONDUCTOR SUSPENSION ASSEMBLIES

3.4.1. GENERAL

The suspension assemblies shall be in a 'V' configuration. The general arrangement of assemblies and attachment details are shown on drawings attached in Volume-III of the Bidding Documents.

All hardware between the point of attachment and the conductors shall be supplied under this Section of Specifications except insulators.

Suspension assemblies required under this Section of the Specifications shall be as specified in clause 3.1.1.1 herein above.

Each phase conductor assembly shall be in a quad bundle with the sub-conductors at each corner of a square. The spacing between any two sub-conductors on each corner of the square shall be 457 mm (18 inches) center to center.

The shielding of the bottom insulator units shall be done keeping the conductor's distance between the bottom insulators and conductors to the minimum without violating other requirements of these Technical Specifications.

All suspension assemblies are designed for short circuit current of 50 kA for duration of 1 sec.

Contours, edges and corners of line hardware shall be rounded to eliminate areas of high corona stress concentration.

All hardware shall be designed for hot line maintenance operation with minimum hole size of 25mm.

The assembly shall be corona free at a voltage of 346kV line to ground.

The manufacturer shall provide the Engineer with E-Field modeling of insulator hardware strings to ascertain electric field distribution and voltage grading.

Corona control and power arc protection devices (guard devices) shall be able to withstand a mechanical load of at least 1.5 kN, acting at an arbitrary point, without being deformed.

3.4.2. CONDUCTOR SUSPENSION CLAMPS

(1) The suspension clamp shall be of Aluminium Alloy, non-magnetic type required to support 795 KCM ACSR "DRAKE" conductor.

(2) Conductor take-off angle shall be in a range of 15 degrees and the minimum radius of curvature of the clamp shall be 360 mm approximately in the center part of the clamp and 250mm at bell ends with the conductor to be always on a rounded smooth surface.

(3) The clamp seat shall be rounded and curved into bell mouth at each end with a rounded lip edge. The clamp shall be shaped in such a way that the clamping pressure on the conductor will increase gradually from the point at which the conductor enters the clamps to a maximum at the center of the clamp. The conductor shall be supported by the suspension clamp for a minimum of 165 mm for the minimum angle of entry of the conductor.

(4) The radius of the curvature of the keeper portion clamp shall not be less than the radius of curvature of the seat of the clamp.

(5) The suspension clamp shall be free to operate in a vertical plane parallel to the conductor up to an angle of at least ±30° to the horizontal. The suspension clamp shall be free to swing transversely to the yoke plate up to an angle of at least 65° from the vertical.

(6) The conductor suspension clamp shall withstand an unbalanced conductor tension of up to 1400 kg without any slippage and must slip at a maximum tension of 1900 kg.

(7) The suspension clamp shall permit the conductor to slip before failure of the conductor occurs.

(8) The conductor suspension clamp shall be designed to withstand a vertical load of 12000 kg without any permanent deformation in any of the components.

(9) The suspension clamp shall be corona free at a voltage of 346 kV line to ground.

(10) The clamps shall have sufficient contact surface to minimize damage due to fault current.

(11) The bodies and keepers shall be of cast or forged high strength corrosion resistant aluminium alloy. Connecting pieces, bolts, nuts and locks washers shall be made of hot dip galvanized steel. Cotter pins shall be made of stainless steel. The wire groove shall be within the limits of 1.0 and 1.15 times the diameter of the conductor.

3.4.3. YOKE PLATE

(1) When the yoke plate is swung about one of the 'V' assembly insulator-string so that the other string becomes slack as in a maximum wind condition, the bottom insulator unit of the slack string shall be able to freely swing downwards relative to the yoke plate up to an angle of at least 75° from its normal position, measured with the top edge of the yoke plate held horizontal.

(2) The clevis connecting the yoke plate to the tongue of the bottom insulator shall be designed in such a way that the bottom insulator unit shall not rotate to such an extent as to contact the yoke plate when the bottom insulator on a slack string is swung to its extreme downward position relative to yoke plate.

(3) The yoke plate shall be free to swing longitudinally to the conductor up to an angle of 20° from the vertical.

(4) The yoke plate shall be made from high grade, hot dipped galvanized steel and subject to normalizing process. The yoke plate shall have round smooth edges and be free of burrs.

3.4.4. CONNECTION FITTINGS

(1) Hot dip galvanized steel fittings suitable for hot line maintenance work shall be provided to perform the following functions:

a) Connect insulators to tower
b) Connect insulators to yoke plate
c) Connect suspension clamp to yoke plate

(2) Bolts and nuts with cotter pins shall be used where the cotter pin can be subjected to abnormal wear or strain. The edges of bolts and nuts shall be rounded smoothly.

(3) Cotter pins shall be made from bronze or stainless steel.

(4) Supplier shall ensure that the hardware assemblies' attachment with the tower plate are compatible and have no orientation problem.

3.4.5. POWER ARC RATING

All suspension assemblies shall be designed for short circuit current of 50kA for duration of 1 sec.
The attachment of the insulator strings to the supports shall be designed to resist the specified short circuit/fault current and fault time so that welding does not occur between the contact surfaces.

Corona control and power arc protection devices (guard devices) shall be thermally designed to resist the fault current with a current density of 80 A/mm^2.

3.5. CONDUCTOR DEAD END ASSEMBLIES

3.5.1. GENERAL

The tension assemblies shall be in a horizontal configuration. The general arrangement of assemblies and attachment details are shown on drawings attached in volume-III of the Bidding Documents.

All hardware between the point of attachment and the compression dead end shall be supplied as per the specified requirement mentioned in this Section of the Technical Specifications except insulators discs.

Tension string assemblies required under this Section of the Specifications shall be as specified in clause 3.1.1.2 herein above.

All hardware from the hole on a horizontal attachment plate of tower up to, but not including the compression dead end shall be supplied as per the specified requirement mentioned in this section of Technical Provisions.

Hot dip galvanized steel fittings suitable for hot line maintenance work shall be provided to perform the following functions:

(a) Connect insulators to tower
(b) Connect insulators to yoke plate
(c) Connect tension clamp to yoke plate

The yoke plates shall be made from high grade, hot dipped galvanized steel and subject to normalizing process. The yoke plates shall have round smooth edges and be free of burrs.

Design of Dead-end Assembly shall not allow rotation of individual sub-conductors.

3.5.2. STRENGTH

The dead end assembly type DE(4) shall withstand without permanent deformation on any of the components, a conductor tension equal to the full rated ultimate strength of the conductor applied simultaneously on all of the four conductors in a bundle.
Corona control and power arc protection devices (guard devices) shall be able to withstand a mechanical load of at least 1.5 kN, acting at an arbitrary point, without being deformed.

3.5.3. TOWER ATTACHMENT FITTINGS

(1) The fittings between the tower/gantry attachment point and the insulator string shall be as per approved tower drawings.

(2) Sufficient articulation shall be provided such that the complete assembly including the insulator units can be attached in the vertical position and then moved to the horizontal position.

(3) The DE (4) assembly should be able to move beyond the horizontal position (upto 45°) without deformation of any component and with sufficient articulation for negative/uplift spans.

(4) Supplier shall ensure that the hardware assemblies' attachment with the tower plate have no compatibility and orientation problem.

3.5.4. HOT LINE MAINTENANCE

(1) Provisions shall be made on both sides of insulator strings for the attachment of a strain carrier to facilitate the replacement of insulator strings for all types of assemblies during hot line maintenance.

(2) These provisions shall be in the form of hot line socket eye below each insulator string on the strain yoke set or with two maintenance holes on each suspension yoke plate or equivalent.

(3) Contours, edges and corners of line hardware shall be rounded to eliminate areas of high corona stress concentration.

(4) The assembly shall be corona free at a voltage of 346 kV line to ground.

3.5.5. ARTICULATION

(1) The assembly shall be designed in such a way that the load will be evenly distributed among the four insulator strings at all time. The assembly shall be designed to withstand a broken conductor without permanent deformation on any of the component when the tension on each of the remaining three conductors is 5500 kg.

(2) The assembly shall be designed to withstand a broken insulator string without permanent deformation of any of the components when the tension on each of the four conductors is 5500 kg. The spacing among the conductors shall be maintained under this condition.

3.5.6. POWER ARC RATING

All dead-end/tension assemblies shall be designed for short circuit current of 50kA for duration of 1 sec.

The attachment of the insulator strings to the supports shall be designed to resist the specified short circuit/fault current and fault time so that welding does not occur between the contact surfaces.

Corona control and power arc protection devices (guard devices) shall be thermally designed to resist the fault current with a current density of 80 A/mm^2.

3.5.7. ELECTRIC FIELD (POTENTIAL) DISTRIBUTION

Finite Element Modeling (FEM) simulations for Electric Field (Potential) distribution shall be performed and submitted for review with any suitable software on the complete insulator hardware assemblies of each type. i.e. VS (4), VJ (4), IJ (4), DE (4), DSD1 (4) and DSD2 (4).

3.6. HARDWARE AND FITTINGS FOR OPGW

All hardware & fittings shall be designed in such a way that no degradation of the optical transmission in the fibers of the wire will occur under all service conditions. The optical fibers shall be freely moveable in the wire under service load.
The OPGW shall be adequately bonded to each steel tower. OPGW suspended or terminated at the tower shall be electrically bonded to the structure by means of a jumper wire of the same type and size as the outer strands of the OPGW. The mechanical hardware shall not be used as the electrical path for conducting lightning surges or fault currents to the steel structure.

3.6.1. OVERHEAD OPGW SUSPENSION ASSEMBLY

At suspension points, armor grip suspension clamps must exclusively be used. The clamp body shall be of Aluminum alloy, which shall preferably be forged. The rod material shall be drawn from Aluminum alloy.

The assembly of the suspension clamp and its hanger shall be able to swing freely in both the longitudinal and transverse directions up to an angle of 70° with the vertical.

The suspension assembly shall withstand a vertical load of 5000 kg without permanent deformation on any of the components. The assembly shall withstand an unbalanced tension of up to 10% of OPGW UTS without any slippage and must slip at a maximum tension of 13% of OPGW UTS.

The general arrangement for suspension set for OPGW is given in Volume-III.

3.6.2. OVERHEAD OPGW TENSION ASSEMBLY

The tension assembly shall consist of a line guard and a preformed dead end, which is placed on the line guard. The line guard shall be laid in the opposite direction of the outer layer of the OPGW and the dead end must be laid in the opposite direction of the line guard.

The length of line guard shall be sufficient to install vibration dampers, if necessary. It shall protect the OPGW against concentrated radial forces in the region of contact between the dead end and the OPGW. All helical rods shall be made of Aluminum clad steel.

The assembly shall have provisions for attachment of pulling fittings for erection and maintenance.

The assembly shall be free to swing so that the clevis will stay in line with the OPGW when the OPGW approaches the tower at any horizontal angle within ±30° from the longitudinal direction of the transmission line and at any vertical angle between the horizontal and 45° below the horizontal.

The general arrangement of tension assemblies for single and double tension set for OPGW are given in Volume-III.

3.6.3. OPGW ATTACHMENT CLAMPS

Attachment clamps to hold the OPGW to the tower for splicing shall be made of Hot dip galvanized steel and shall be provided as shown in the drawing given in Volume-III.

3.7. PARALLEL GROOVE CONNECTORS

The material of parallel-groove connectors shall be Aluminum Alloy for OPGW.

3.8. TESTS

The following section details the testing requirements of hardware assemblies.

3.8.1. TYPE TESTS

Following type tests are required to be performed as per IEC 61284 (expect power arc test and galvanizing tests). Type tests shall also be done if dimensions or materials described on manufacturers' drawings are modified or if manufacturing processes or manufacturing place have been changed.

(i) Visual Examination, Dimensional Check and Material Verification.
Conformity of manufacturing process, shape, coating, surface finish, markings, dimensions and material of the hardware fitting with the contract drawings and technical provisions will be ensured.

(ii) Hot Dip Galvanizing Tests as per relevant ASTM Standards.
Tests shall be performed as ASTM Standard A153.

(iii) Mechanical Test:
On each complete assembly as per approved drawing of hardware. The Specified Minimum damage load (SMDL) shall be 65% of Specified Minimum Failing Load (SMFL).

(iv) Slippage to Conductor and OPGW Suspension and Tension Clamps:
On conductor and OPGW suspension clamps and OPGW tension clamps.

Each conductor suspension clamp must be separately tested. A load shall be applied parallel to the axis of the conductor to test longitudinal slip strength.

Prior to testing, the clamp shall be installed on the conductor sample while it is under required slip strength as specified on the Design Requirements Drawings, with the Contractor's recommended bolt torques (where applicable).

The clamps of the conductor suspension assembly must withstand the longitudinal load specified herein above without exceeding 6 mm initial slip. Initial slip shall be defined as the permanent displacement between the conductor and the clamp, measured after removal of the load.

After the initial loading test, the load shall be increased until continuous slip occurs, and this load is to be reported.

(v) Magnetic Losses Test:
The test shall be performed on conductor suspension clamp to ascertain the magnetic losses.

(vi) Corona (Visible Discharge) and RIV Test:
The corona test shall be performed on complete insulator assemblies of each type i.e. VS(4), DE(4), I(J4), & VJ(4).

The test shall be performed on complete insulator suspension as well as tension strings completely assembled with all fittings in a manner as nearly as possible to the arrangement to be used. The assemblies when tested shall not exhibit any sign of visible or audible corona at a power frequency voltage of 346 kV line to ground.

The RIV test shall be performed with 60dBμV at 0.5 MHz measuring frequency as the limiting value of radio interference characteristic.

The assembly shall be configured using the same insulator units specified for the project.

For both series of measurements, the RIV vs. conductor surface voltage gradient is to be plotted and reported.
Corona inception and extinction observation will be carried out both for negative and positive corona.

(vii) Power Arc Test:
The power arc test shall be performed in accordance with IEC 61467 for test series "X" test circuit "B" on hardware assembly type VS(4), & DE (4) including compression dead end splices. The assembly shall be configured using the same insulator units specified for the project.
High speed video recording of the test will be made and provided to the Engineer.

(viii) Tensile Test on individual hardware items:
Test shall be performed in accordance with IEC 61284 on each hardware item.

3.8.2. SAMPLE TESTS

Sample tests on each item of hardware shall be made to verify the quality and workmanship. The number of samples shall be as per BS3288-1. However, if the

sample quantity is less than 100 at least one (01) sample shall be subjected to mechanical tests. The sample tests are to be performed as per IEC 61284 (except galvanization tests). The sample tests to be performed are as follows:

(i) Visual examination and Material Verification (on each item of hardware)
Conformity of manufacturing process, shape, coating, surface finish, markings, and material of the hardware fitting with the contract drawings and technical provisions will be ensured. During sample testing, the Contractor shall keep/maintain at his Works each type of complete hardware assembly previously subjected to corona type tests. The sample test shall include a comparison of shape and surface finish of the mass production with the corona type tested samples. All material that does not meet/match surface finish of corona type tested samples shall be rejected.

(ii) Verification of dimensions (on each item of hardware):

The binding dimensions of the hardware shall be measured and shall be as shown on the relevant approved drawings subject to the tolerances given in BS 3288-1.

(iii) Prototype Assembly:
Complete assembly will be assembled as per approved drawing to rule out any compatibility or orientation issue.

(iv) Verification of Assembly Articulation and Free Movement
Articulation and movement requirements of each assembly and its components as stated in the technical provisions herein above shall be verified.

(v) Mechanical test
On each complete assembly as per approved drawing of hardware. The Specified Minimum damage load (SMDL) shall be 65% of Specified Minimum Failing Load (SMFL).

(vi) Slippage to Conductor and OPGW Suspension and Tension Clamps:

The test shall be performed on conductor suspension clamp and OPGW suspension and tension clamps.

Each conductor suspension clamp must be separately tested. A load shall be applied parallel to the axis of the conductor to test longitudinal slip strength.

Prior to testing, the clamp shall be installed on the conductor sample while it is under required slip strength as specified on the Design Requirements Drawings, with the Contractor's recommended bolt torques (where applicable).

The clamps of the conductor suspension assembly must withstand the longitudinal load specified herein above without exceeding 6 mm initial slip. Initial slip shall be defined as the permanent displacement between the conductor and the clamp, measured after removal of the load.

After the initial loading test, the load shall be increased until continuous slip occurs, and this load is to be reported.

(vii) Galvanizing test:

Following tests shall be carried out on all ferrous parts complying with the relevant ASTM standards.

- Weight of zinc coating
- Uniformity of zinc coating
- Adherence of zinc coating
- Purity of zinc coating (99.995%

4. CONDUCTOR ACCESSORIES

This section of Technical Provisions specifies he minimum technical requirements for design, engineering, manufacture, inspection and testing of accessories for ACSR "DRAKE" Conductor to be used on 500kV double circuit quad bundle transmission line.

The material offered shall be suitable to sustain the heavy atmospheric pollution without being affected by it and remaining free from corrosion.

Each item shall be marked with manufacturer trade mark, strength and year of manufacture.

The accessories to be furnished are as follows:

1. Conductor compression splices
2. Conductor repair sleeves
3. Conductor compression dead end splices
4. Compression dies

4.1. DETAILED REQUIREMENTS

The compression splices shall not permit slipping of or cause damage to or failure of the complete line conductor or any part thereof at a load less than ninety-five percent (95%) of the ultimate strength of the conductor.

Contours and edges of line accessories shall be rounded to eliminate areas of high corona stress concentration.

The line accessories shall be corona free at a voltage of 346 kV line to ground.

The conductance per unit length of the splices shall not be less than that of the conductor itself. The temperature rise shall not be greater than the temperature rise in the conductor.

All splices shall be pre-filled with appropriate filler compound. Besides, the filler compound (to cover at least 5% of the supplied accessories) shall also be supplied separately. The open mouths of the splices shall be capped properly to provide protection against moisture and dust etc.

All current carrying parts shall be coated with plastic to inhibit corrosion on such surfaces during transportation. The current carrying jumper pads shall be free from protrusions, nicks or burrs to prevent possibility of undesirable hot spots

The ends of compression accessories (mid span joint, dead-end joint and jumper terminals) shall be tapered in such a manner that the applied pressure shall be gradually reduced to zero on that part of the conductor leaving the accessory and that the conductor stresses caused from bending and vibration reduced to a minimum.

The aluminum metal parts shall be anodic oxide coated in accordance with ASTM B580.

The compression fittings shall meet the specification requirements of Duty of Heat Cycling as per Clause 4.5.1(iv) herein when subjected to a Heat Cycle Test. This requirement shall be met for the compression dead end assembly when bolted jumper terminals are included in the test.

On each compression accessory, manufacturer's name/trade mark, country of origin, catalog number, year of manufacturing, die size, start knurl, stop knurl and knurl locations (if applicable) and name/code of conductor shall be stamped legible.

The purity of Zinc used for galvanization of all ferrous articles, components and items shall be 99.995%.

4.2. CONDUCTOR COMPRESSION SPLICE

The conductor splice shall be of two piece compression type consisting of inner galvanized steel sleeve for jointing steel core and an outer aluminum alloy sleeve for connecting aluminum strands for ACSR conductor. The splice shall be suitable for two step compression requiring separate compression for steel sleeve for ACSR conductor. The splice shall develop at least ninety-five percent (95%) of the ultimate strength of the conductor.

4.3. CONDUCTOR REPAIR SLEEVE

Repair sleeve shall be of aluminum alloy open type, consisting of body and keeper, which interlock when compressed. The sleeve should restore 95% of the conductor rated strength with a condition where no more than 1/3 of the aluminum strands are damaged.

4.4. CONDUCTOR COMPRESSION DEAD END SPLICE

Dead End compression splice for ACSR "DRAKE" conductor shall be of two piece compression type consisting of single aluminum alloy body, steel body of the eye and provided with a four-hole terminal pad and jumper compression sleeve. The steel eye shall be vertical as shown in the drawing given in Volume-III.

The compression dead end shall be supplied with one steel compression dead-end body and shall be suitable for two step compressions requiring separate compression for aluminum alloy body on steel eye.

The required nuts, bolts and spring washers/Belleville washers to connect the jumper terminal pad to the dead end terminal pad shall be supplied and made of aluminum alloy/stainless steel. The bolts, nuts and washers shall be M16 aluminum alloy or M12 stainless steel.

The jumper and terminal connector and its pad shall be constructed with a 15 degree angle, which permits the terminal connector to be bolted in either the straight or the 30 degree position. The jumper sleeve shall be one piece compression type. Both sides of the pad shall have even surfaces for better electrical contact.

The Supplier shall provide sufficient electrical joint compound as per the properties stated herein above for the supplied dead end splices.

Pads of the jumper terminal connector and dead end compression joint shall be factory protected by removable plastic.

4.5. TESTS

The following section details the testing and inspection requirements for conductor accessories.

4.5.1. TYPE TESTS

The following type tests are required to be performed as per IEC 61284 (except galvanizing). Type tests shall also be done if dimensions or materials described on manufacturers' drawings are modified or if manufacturing processes or manufacturing place have been changed.

i) Visual Examination, Dimensional Check and Material Verification.
Conformity of manufacturing process, shape, coating, surface finish, markings, dimensions and material of the compression clamps and accessories with the contract drawings and technical provisions will be ensured.

ii) Hot Galvanizing Tests on ferrous parts as per relevant ASTM Standards.

iii) Mechanical Test:
Test piece shall be assembled in accordance with manufacturer's recommendations on conductor of the size and type with which it is to be used. The fittings when tested in accordance with BS 3288-1 or ANSI C119.4 shall withstand a load of minimum ninety five percent (95%) of the rated strength of the conductor. There shall be no movement of the conductor relative to the connector and no failure of the connector due to slip during one-minute hold period at ninety percent (90%) of the conductor rated strength.

iv) Heat Cycle Test
(On conductor compression splice, repair sleeve and conductor compression dead end only):

The test current shall be the power frequency current and should raise the surface temperature (temperature rise plus ambient temperature) of the conductor to 140 degrees centigrade. The tests shall be carried out as per Clause 13.5.2 of IEC 61284 with number of cycles 'N' as 500.

v) Corona (Visible Discharge) and RIV Test:
The connectors shall be attached to a length of conductor of the size and type with which these are to be used. The connectors when tested shall not exhibit any sign of visible or audible corona at a power frequency voltage of 346 kV line to ground. The test shall be performed on a quad bundle conductors arrangement with inter spacing of 457 mm.

The RIV test shall be performed with 60dB μV as the limiting value of radio interference characteristic.

vi) Fault Current Test
This test shall be made on conductor dead end body in accordance with ANSI C119.4 against a system short circuit current of 50 kA rms.

4.5.2. SAMPLE TESTS

Sample tests shall be made to verify the quality and workmanship. The number of samples shall be selected as per BS 3288-1. However, if the sample quantity is less than 100 at least one (01) sample shall be subjected to mechanical tests.

The following sample tests shall be performed on all conductor fittings as per IEC 61284 (except resistance and galvanizing tests):

a. Visual Examination, Dimensional Check and Material Verification.
Conformity of manufacturing process, shape, coating, surface finish, markings, dimensions and material of the compression clamps and accessories with the contract drawings and technical provisions will be ensured. These shall include length and diameter of the connectors before and after compression and percentage elongation. Pads of the jumper terminal connector and dead end compression joint shall be factory protected by removable plastic. All sides of the current carrying jumper pads shall be free from protrusions, nicks or burrs to prevent possibility of undesirable hot spots.

b. Mechanical Test:
Test piece shall be assembled in accordance with Contractor's recommendations on conductor of the size and type with which it is to be used. The fittings shall be tested in accordance with IEC 61284. Repair sleeve shall be tested to ensure compliance with provisions of these specifications.

c. Resistance Test:
The electrical resistance of the accessories when tested in accordance with Clause 13.4.5.1 of IEC 61284 shall not exceed seventy five percent (75%) of the measured resistance of the equivalent length of the conductor. The test shall be made with a direct current and test shall be repeated with the polarity and the average of the two results taken as the measured value.

d. Galvanizing Tests:
These tests shall be carried out on all ferrous parts complying with the following requirements:

a) Weight of Zinc coating
b) Uniformity of Zinc coating
c) Adherence of Zinc coating
d) Purity of Zinc coating (99.995%)

These tests shall be performed in accordance with relevant ASTM Standards.

Note: The compression of the accessories during type/sample testing shall be carried out with the dies to be supplied by the Contractor under this Contract.

4.6. COMPRESSION DIES FOR ACSR DRAKE

Conductor compression dies shall be suitable for use on accessories of 795 KCM "DRAKE" Conductor. The dies shall be of steel having hexagonal configuration. The design of all compression fittings shall be such that only one pair of dies is necessary for one conductor type.

The dies (conductor) should be compatible with type of compressors and accessories being supplied.

In addition each die cavity will be imprinted with die section/identification number so that the same is embossed on the compression fitting each time a crimp is made.

The Supplier shall provide the detailed drawings along with the dies material properties for approval.

4.7. FILLER COMPOUND

The filler compound shall be of suitable material to be used as filler for compression accessories. The filler should effectively seal out the compression fitting against air and moisture. The filler compound shall be supplied in a package/carton of hundred (100) tubes each having 0.5 kg filler weight.

4.8. ELECTRICAL JOINT COMPOUND

The electrical joint compound shall be of suitable material to be used for making aluminum-to-aluminum & flat-to-flat surface contacts such as terminal to dead end. The compound shall be an active chemical in a grease type sealer and shall act to dissolve the oxide film and seal the joint against moisture. The flow point of the compound shall not be less than 100°C. The flash point should not be less 190°C and alkalinity/basicity $\leq$ 0.1%. The compound shall be supplied in a package/carton of 10 tubes each having 0.25 kg compound weight.

5. INSULATORS

This section of Technical Provisions specifies the minimum technical requirements for design, engineering, manufacture, inspection, testing and performance of Toughened Glass Disc/Non Ceramic Composite Insulators.

5.1. TOUGHENED GLASS INSULATORS

Toughened glass insulators shall conform to the specified requirements of NTDC Specifications (P-8B:2020) including its latest revision to date, appended herewith as Appendix-I: Specifications P-8B: 2020 – Toughened Glass Disc Insulators.

The following amendments may please be incorporated in aforementioned Specifications and are to be considered integral part of the specifications:

A. Clause 7.1 "Type (Design) Tests"

Following to be added at the end of clause 7.1:

b. Type (Design) Tests on Complete Insulator String with hardware fittings:

i. Wet Power frequency test (As per IEC-60383)
ii. Dry Lightening Impulse Withstand Voltage Test (As per IEC-60383)
iii. Wet Switching Impulse withstand voltage test (As per IEC 60383 & IEC 60060-1
iv. Corona and RIV Test (as per clause 8.1.17 of this specification)
v. Mechanical strength test (as per clause 8.1.18 of this specification)
vi. Voltage Distribution Test (as per clause 8.1.19 of this specification)
vii. Power Arc Test (as per IEC 61467)

All the type tests specified herein above in clause 7.1 (b) shall be performed on hardware dead end assembly including compression dead end splices (for non-terminal span) for tower type DA1, DD1 & DGM.

B. Following new Clauses 8.1.17, 8.1.18 & 8.1.19 to be added after clause 8.1.16:

8.1.17 Corona (Visible Discharge) and RIV Test

The test shall be performed on complete strings completely assembled with all fittings in a manner as nearly as possible to the arrangement to be used. The assemblies when tested shall not exhibit any sign of visible or audible corona at a power frequency voltage of 346 kV line to ground.

The RIV test shall be performed with 60dBμV at 0.5 MHz measuring frequency as the limiting value of radio interference characteristic.

For both series of measurements the RIV vs. conductor surface voltage gradient is to be plotted and reported.

Corona inception and extinction observation will be carried out both for negative and positive corona.

8.1.18 Mechanical Strength Test

The complete insulator dead end strings including all its fitting (excluding arcing horn, corona control ring, grading ring) shall be subjected to a load equal to 50% of the specified minimum failure load (SFL) which shall be increased at a steady rate to 67% of the minimum SFL 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 disassemble 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 SFL and the load shall be further increased at a steady rate till the specified minimum SFL 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.

8.1.19 Voltage Distribution Test

The voltage distribution test shall be carried out as per test procedure and result verification method proposed by the hardware manufacturer in Schedule-F to Bid "Specific Plant Data for Complete hardware strings including Insulators". The result obtained shall be converted into percentage. Limiting values for voltage across individual insulators in suspension insulator strings and tension insulator strings shall be specified by the manufacturer and relevant calculations with references from recognized international standards/papers/studies shall be attached with the bid to justify limiting values.

5.2. NON CERAMIC COMPOSITE INSULATORS

Non Ceramic Composite insulators shall conform to the specified requirements of NTDC Specifications (TLMS-8A:2017) including its latest revision to date, appended herewith as Appendix-II: Specification TLMS-8A:2017 – Non Ceramic Composite Insulators For Overhead Transmission Lines 132kV/220kV/500kV.

The following amendments may please be incorporated in aforementioned Specifications and are to be considered integral part of the specifications:

A. Clause 4.2 "Design Criteria"

Clause 4.2.4 to be deleted and replaced with the following:

4.2.4 kmz files of routes of both transmission lines are provided with the bidding documents. The Contractor shall be deemed to have inspected and examined the Site and its surroundings and information available in connection therewith including service conditions, pollution and metrological data and use that as the basis of design criteria.

B. Clause 4.4 "Material and Workmanship"

Clause 4.4.2 to be deleted and replaced with the following:

4.4.2 The composite insulator surface shall be shaped and spaced for effective natural cleaning and effective use of leakage distance for coastal/desert/humid/industrially polluted and other environments as determined from kmz files provided by the purchaser.

C. Clause 4.3 "Ratings"

Table-1 in clause 4.3.1 to be deleted and replaced with the following table:

Nominal System Voltage (kV)	Coupling (IEC 60120/60471)	Specified Mechanical Load (SML)		Min. Leakage Distance (mm)	Maximum Permissible Section Length (mm)
		Suspension Application (kN)	Tension Application (kN)		
500	Tongue & Clevis or Ball & Socket	240 120	- -	15808	4930

D. Clause 6.1 "Type Tests":

Clause 6.1.2 to be deleted and replaced with the following:

6.1.2 The following type tests are to be carried out in accordance with the requirement and methods laid down in the standards/clauses mentioned therewith.

On Complete Composite Insulator along with Hardware Fittings		
1.	Wet power frequency test	IEC 61109
2.	Dry lightning impulse withstand voltage test	IEC 61109
3.	Wet switching impulse withstand voltage test	IEC-61109
4.	Power arc test	IEC 61467
5.	Corona and RIV test	As per Clause 6.1.5
6.	Voltage Distribution Test	As per newly added Clause 6.1.11
7.	Mechanical Strength Test	As per newly added Clause 6.1.12
All the type tests specified herein above shall be performed on hardware suspension assembly for DS1 tower and Vee jumper suspension assembly for tower type DA1, DD1 & DGM and I jumper assembly of tower type DGM.		
On Composite Insulator Units		
1.	Tests on interfaces and connections of end fittings a) Sudden load release pre-stressing b) Thermal-mechanical pre-stressing c) Water immersion pre-stressing d) Verification tests e) Visual examination f) Steep-front impulse voltage test g) Dry power-frequency voltage test	IEC-61109
2.	Tests on shed and housing material a) Hardness test b) Accelerated weathering test c) Tracking and erosion test d) Flammability test	IEC-61109
	e) Artificial Pollution Test	As per Clause 6.1.4
3.	Tests on core material a) Dye penetration test b) Water diffusion test	IEC-61109
4.	Assembled core-load time test a) Determination of the average failing load of the core of the assembled insulator b) Verification of 96 h Withstand test c) Control of the slope of the strength-time curve of the insulator	IEC-61109
5.	Damage limit proof test and test of the tightness of the interface between end fittings and insulator housing	IEC-61109
7.	Artificial pollution test	As per Clause 6.1.4
8.	High pressure water withstand test	As per Clause 6.1.6
9.	Brittle fracture resistance test	As per Clause 6.1.7
10.	Torsional load test	As per Clause 6.1.8

11.	Grading device test	As per Clause 6.1.9
12.	Recovery of hydrophobicity test	As per Clause 6.1.10

E. Clause 6.1.3 "5000 hours Ageing test" is to be deleted.

F. ANNEX-I: A "Electrical System Particulars"
Short Circuit Level in 1 second is to be changed to 50kA instead of 63kA.

G. ANNEX-I: B "Service Conditions" is to be deleted.

H. Following new Clauses 6.1.11 & 6.1.12 to be added after clause 6.1.10:

6.1.11 Mechanical Strength Test

The complete insulator suspension strings including all its fitting (excluding arcing horn, corona control ring, grading ring) shall be subjected to a load equal to 50% of the specified minimum failure load (SFL) which shall be increased at a steady rate to 67% of the minimum SFL 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 disassemble 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 SFL and the load shall be further increased at a steady rate till the specified minimum SFL 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.

6.1.12 Voltage Distribution Test

The voltage distribution test shall be carried out as per test procedure and result verification method proposed by the hardware manufacturer in Schedule-F to Bid "Specific Plant Data for Complete hardware strings including Insulators". The result obtained shall be converted into percentage. Limiting values for voltage across individual insulators in suspension insulator strings and tension insulator strings shall be specified by the manufacturer and relevant calculations with references from recognized international standards/papers/studies shall be attached with the bid to justify limiting values.

6. SPACER DAMPERS & RIGID SPACERS FOR CONDUCTOR

This specification specifies the minimum technical requirements for design, manufacture, inspection, testing and performance of spacer dampers and rigid spacers for quad-bundle conductor and rigid spacers for quad bundle conductor for use on 500kV transmission line.

6.1. DETAILED REQUIREMENTS

6.1.1. GENERAL

It should be suitable to sustain the heavy atmospheric pollution without being affected by it and remaining free from corrosion.

Each item shall be marked with manufacturer trade mark, strength, year of manufacture and Contract number.

The spacer dampers shall be designed for use on quad-bundle 795 KCM 26/7 ACSR "DRAKE" conductor.

The manufacturer shall study the sag-tension data, environmental and actual site conditions to ascertain the required quantity and spacing of vibration dampers and spacer dampers. The manufacturer shall provide clear and complete description of installation procedure along with positioning tables for vibration dampers and spacer dampers, which shall include the datum point for sub-span length measurements, both for suspension and tension span extremities, the position of spacer damper in relation to mid-span joints and other devices installed on the conductors.

The Supplier shall guarantee that the proposed vibration damping systems will be adequate for the purpose and capable to perform within the established limits of permissible vibration.

All items furnished shall be standard manufactured products, as supplied to the major portion of utility industry.

The spacer dampers shall be designed to prevent physical contact between sub conductors in sub spans between spacers, except during the passage of short circuit currents when the possibility of contact is accepted provided that the specified spacing is restored immediately following fault clearance.

During installation, maintenance and service (including short circuit conditions), it should withstand mechanical loads without any component failure or any permanent deformation.

The spacer dampers shall be designed so as to ensure that individual components will not become loose in service and permit relative vertical, horizontal, torsional and axial movement between sub conductors.

All materials shall be of recent manufacture, unused and free of defects or irregularities and shall be resistant to corrosion formed by electrolytic action due to application of dissimilar materials.

Workmanship shall follow the best practices of the industry. All components of the same design and designation shall be identical and like components shall be interchangeable.

Where different materials are used in the spacer dampers, then the design shall ensure that neither electrochemical action nor any other adverse effects associated with dissimilar materials can occur.

All ferrous components shall be protected by zinc coating, nuts and screws by hot dip galvanizing and washers by zinc plating.

The clamp bore shall be smooth and free of projections and shall not be sand blasted or refilled to increase artificially the coefficient of friction between the clamp and the conductor as these can cause damage to the conductor.

Screw and bolt threads shall be in accordance with ANSI B.1.1. "Unified Screw Threads" class 2A. All internal threads shall be machined after manufacture to allow for galvanizing and conforming to appropriate class tolerances.

All ferrous metal shall be galvanized to conform to ASTM A153 and A239 specifications. Electrolytic zinc plating shall be in accordance with ASTM A164 and heat treated to overcome hydrogen embrittlement.

Anodic coating for Aluminum and Aluminum Alloy shall be in accordance with U.S. Military Specification MIL- A-8025 C.

The purity of Zinc used for galvanization of all ferrous articles, components and items shall be 99.995%.

The Spacer Damper’s clamps shall be designed in a manner to ensure metal to metal contact.

6.1.2. MANUFACTURER’S DRAWINGS

The Supplier shall submit detailed drawings of the assemblies and component parts along with isometric views, which show all dimensions and necessary tolerances.

Catalog and part numbers including material and specified finishes and coatings shall be included.

Assembly drawings shall include but not limited to following:

- Installation instructions
- Rated mechanical strength in tension and compression
- Design installation torque (with tolerance) for break-away head bolts or cap screws
- Clamp displacement (longitudinal, vertical, conical & transverse)
- Arm length and angle
- Weight of the assembly
- Materials and standards applied
- Typical values of elastomer/damping material

- Torsional stiffness and damping constant values type tested or declared by the contractor.
- Resistance of Elastomer

6.2. CONDUCTOR SPACER DAMPERS

6.2.1. PHYSICAL REQUIREMENTS

The spacer dampers shall be designed for use on quad-bundle 795 KCM 26/7 ACSR "DRAKE" conductor.

All break-away bolt heads must be oriented for ground-level viewing.

The spacer-dampers shall be capable of being installed and removed from energized lines by means of hot-line tools. The Supplier shall furnish detailed information on tools needed and procedure required to perform the hot-line removal and installation of spacer-dampers.

6.2.2. ENERGY ABSORBING ASSEMBLY

The energy absorbing assembly shall have the ability to:

a. Withstand any heat generated
b. Avoid any displacement in the housings
c. Resist bond failure
d. Avoid any other damage which would appreciably decrease the damping efficiency.

Where elastomers or other non-metallic materials are used, they shall be capable of withstanding temperatures of -10°C to +100°C without permanent loss of essential properties. Assembly shall be designed to provide effective damping for the line technical and environmental conditions prevailing in the area.

The elastomer materials or other energy absorbing assembly shall have adequate resistance to the effects of ozone, ultra violet radiation, dust particles and other atmospheric contaminants over the entire temperature range, including fatigue and work softening.

The energy absorbing assembly shall be electrically conductive. The conductivity of individual components shall be stated by the Supplier.

6.2.3. CLAMPS AND BOLTS

Clamps, which are fastened with bolts, shall be provided with breakaway heads or caps and suitable washers. The bolts shall be lubricated with an appropriate lubricant.

The clamps shall be designed so that they will seat firmly and smoothly on the conductor with sufficient pressure to compensate for creep, cold flow, and/or nesting.

The arm clamp shall be of aluminum alloy commensurate with the design requirements. The clamp cap shall also be of aluminum alloy.

The arm clamp and clamp cap shall each have an effective length in bearing on the conductor of not less than 70 mm for metal surfaced clamps. Exit radii shall be excluded in meeting this requirement.

Bolted type spacer assembly clamps shall be capable of withstanding a torque equal to twice of nominal design installation torque, without failure of component parts when installed on the conductor. This value shall be obtained by applying the torque to the lower head of the breakaway bolt or cap screw.

Clamping bolts shall be M16 aluminum alloy or minimum M12 stainless steel with a break-away type shear head bolt or M12 galvanized steel equipped with a break-away type cap made of zinc alloy. The break-away shear head type bolt or break-away cap screw for galvanized steel bolts shall be furnished with a wrench stop to prevent the socket from engaging the lower head during installation.

The torque required to break away the upper head from the lower head shall be within a tolerance of plus or minus ten percent (10%) of the Supplier's design value.

The break-away head bolts or cap screws shall be fabricated from 6101-T8 or AA7075 high strength aluminum alloy or stainless steel (austenitic stainless steel ANSI 300 series) or low or medium carbon steel and in accordance to ISO 898 property class either 8.8 or 6.8 together with hexagonal nuts of appropriate class. Any other material must be approved by the Engineer.

The anodization for aluminum alloy shall be according to US Military Specifications MIL A-8025C.

Clamping bolts or cap screws are to be equipped with steel Belleville type spring washers designed to compensate for a potential relaxation in bolt tension, the washer(s) shall be displaced no more than 30% of the total as-flat deflection at nominal installation torque, the washer(s) shall have a recoverable deflection of at least 0.9 mm as determined by the difference between the loaded and subsequent unloaded height. The Supplier can use more Belleville washers to control the clamp bolt loosening. At the manufacturer nominal installation torque the Belleville washer(s) should not have a permanent deflection greater than 10% of the recoverable deflection.

It is recommended to equip at least two (02) Belleville washers.

The material of Belleville washer and other spring elements are made of 50CrV4 chromium-vanadium steel or Ck75 unalloyed steel.

6.2.4. PERFORMANCE REQUIREMENTS

The Supplier will submit during design review stage, the spacer-damper's proven ability to effectively suppress sub-conductor oscillation and to control Aeolian vibration as per criteria laid down in Clause 6.2.5.

The dynamic strain caused by vibration in the vertical direction shall not exceed 150 micro-meter/meter peak-to-peak for ACSR “DRAKE” Conductor, at the suspension point as measured according to the method recommended in IEEE 1368.

In terms of the f y_{max} parameter, the maximum Aeolian vibration level of the conductor shall not exceed 40 mm/s 0-peak for ACSR Drake Conductor

Bending amplitude when measured in accordance with IEEE Std. 1368 “IEEE Guide for Aeolian Vibration Field Measurements of Overhead Conductors” shall not exceed 0.23 mm (9 mils) 0-peak value.

The maximum subspan oscillation amplitude of each sub-conductor shall not exceed 130 mm (peak to peak).

The normal distance between spacer dampers (sub-span spacing) shall not exceed fifty-five (55) meter.

Spacer dampers shall not be located on or close to the conductor splice and shall be positioned at a minimum distance of 2 meters before or after the splice area within the manufacturer’s recommended spacing tolerances.

Proposed spacer damper shall meet the performance requirements without failure in service or damage to conductors. For the purposes of these specifications, the word "failure" as applied to qualification/design tests and service conditions shall mean the following:

a. Failure of any component, part, or damage to conductor other than the normal deformation which results from conductor clamping action.

b. The torque in clamp bolt or bolts is reduced to such an extent that the conductor has rotated or slipped in the clamp or if the torque is reduced to 60 percent of the Supplier's recommended installing torque, regardless of whether the conductor rotates or slips in the clamp. All torque measurements will be taken in the tightening direction.

c. Any wear of any conductor strand which exceeds 70 percent in width or 10 percent in depth of the conductor strand diameter shall constitute a failure.

d. Cuts/Cracks in Elastomer material after Conical Fatigue Test.

6.2.5. ANALYTICAL VIBRATION DAMPING STUDY

Vibration study of the spacer dampers for the transmission line shall be carried out using computer software (capable of calculating vibration amplitude and strain at conductor suspension clamp and spacer damper’s clamp and benchmarked/validated with vibration data from the field - preferably ATTRA). The vibration behavior shall be observed by simulating the load due to various kinds of conductor motions as per the environment parameters such as temperature, wind speed and EDS etc. The final staggering scheme of the spacer dampers shall be mentioned according to the bending strain curve.

The Supplier shall submit Analytical Damping Study Report to ascertain the effectiveness of the proposed damping system by Supplier.

The Analytical Damping Study furnished with the Bid should prove that the damping system and quantity of spacer and Stockbridge dampers proposed by the manufacturer/bidder adequately meets the Aeolian, Sub-span Oscillation and Bending Strain performance requirements stipulated in the Technical Provisions.

The Analytical Damping Study furnished should include and clearly indicate the following parameters:

i. Wind energy input.

ii. Conductor/wire characteristics.

iii. Spacer damper hinge stiffness and damping parameters as a function of frequency (2-50 Hz) measured at 100 mm/s constant vibration velocity.

The manufacturer/bidder will provide Type Test Reports of Characterization of the Elastic and Damping Properties (IEC 61854 and as a function of frequency) from an independent accredited laboratory as called for in the relevant provisions of the Bidding Documents to authenticate the spacer-damper characteristics included in the Analytical Damping Study.

In case of unavailability of acceptable type test reports as required herein above, the manufacturer will declare spacer damper stiffness & damping constants as "ASSUMED". Subsequently after the required type testing, the manufacturer will revise and submit its Analytical Damping Study using the type tested spacer damper stiffness & damping constants.

iv. Spacer damper dynamic properties including masses and moments of inertia.

v. Criteria for selection of sub-span ratios.

vi. Aeolian & sub-span vibration amplitudes alongwith bending strains for span lengths of 260, 320, 380, 440 & 680 meters at -5°C, 25°C & 55°C before and after Energy Absorbing + Fatigue Tests (as per clauses 6.2.8.5, 6.2.8.6, 6.2.8.7) and after Temperature Sensitivity Test (as per clause 6.2.8.12 (vii)) for Spacer Damper.

vii. Aeolian vibration & bending strain curves covering at least 0-80Hz frequency range.

viii. Spacer damper placement charts (damper staggering scheme) for span lengths 50 - 1000 meters.

ix. Damper placement schematics/drawings indicating the governing distances for both suspension and tension span extremities.

x. Manufacturer’s spacer damper installation instructions and recommendations.

The manufacturer/bidder will provide the Engineer with simulation files that have been used in preparation of the Analytical Damping Study for substantiation and verification of the Damping Study Results and the proposed damping system.

6.2.6. ELECTRO-MECHANICAL CHARACTERISTICS

The spacer damper shall be designed to be free from visible corona when viewed in a darkened laboratory at a system voltage of 346 kV (line to ground).

The spacer damper shall be designed to withstand the electromagnetic forces resulting from short-circuit currents of 50,000 Amps. r.m.s. symmetrical for 4 cycles (50 Hz.).

The load arising from such a fault condition is estimated to be towards geometric center of the units on basis of relationship given in the IEEE Paper 31TP 65.707 by C. Manuzio, "An investigation of the Forces of Bundle Conductor Spacers Under Fault Conditions".

6.2.7. PERFORMANCE GUARANTEE FOR DAMPING SYSTEMS

By way of further definition, all the guarantee provisions set out in the Contract Documents shall extend to cover not only the individual pieces of material supplied but also the capability of the spacer damper system to control Aeolian vibration and sub-span oscillations to within accepted safe limits with no other damping device fitted to the line, when installed in accordance with the Supplier's installation instructions and recommended sub-span locations.

The spacer damper system will be considered defective if unacceptable vibrations above the limits as defined in Clause 6.2.4 herein occur in the specified span fitted with the Supplier's unit(s). Should these vibrations exceed the specified limits, additional damping devices shall be provided, free of charge, by the Supplier to reduce Aeolian vibration amplitude on affected spans to acceptable safe limits.

The spacer damper system shall also control sub- conductor oscillation.

This guarantee in respect of system performance is applicable under the basic line data and environmental conditions prevailing in the area.

6.2.8. QUALIFICATION TESTS REQUIREMENTS

6.2.8.1. General

The following tests shall be performed by the Supplier to establish the characteristics of the spacer dampers when installed on the conductor and to assure compliance with all requirements specified.

Certified copies of type test reports if already carried out on the identical spacers including test data which show that the spacer damper assemblies meet all the requirements of these specifications shall be submitted. The performance of tests must have been completed and test data approved before any of the spacer assemblies are shipped. Following tests are required to be performed on the first offered lot on each of at least three assemblies in the order prescribed below or as agreed during the testing. The failure of any one sample shall constitute failure of the design.

6.2.8.2. Clamp Slippage Tests at Ambient Temperature

(i) Longitudinal Slip Test

The Spacer Damper shall be installed in accordance with manufacturer's installation instructions on a minimum length of 4.0 m conductor tensioned to approximately 20% of its rated strength. A load shall be applied to each clamp parallel to the axis of the conductor. The clamps of the spacer assembly that have successfully passed the longitudinal displacement and vertical vibration tests as per clause 6.2.8.5 (b) and (c) shall withstand a load of 440 daN for metal-surfaced clamps for a minimum period of 60 sec without slipping on the conductor. Clamps shall not be re-installed and bolts or cap screws shall not be re-torqued after the longitudinal displacement and vertical vibration tests. The loads at which initial slip and continual slip of each spacer occurs shall be recorded. The initial slip load is defined as the load at which the spacer clamp moves 0.5 mm or more on the conductor and the continual slip load is defined as the maximum obtainable load.

(ii) Torsional Slip Test

Torsional slip test shall be performed according to IEC 61854 clause 7.5.1.2 (A) with a specified torsional load of 40Nm or higher.

6.2.8.3. Flexibility Test

These tests are defined to ensure that spacer damper is flexible enough to accommodate any expected relative movement at the sub-conductors during normal working life of the line without damage to the conductor or the spacer.

The spacer shall be installed on a length of a twin bundle tensioned at 20 % of its rated tensile strength, tightening the clamp bolts to the specified installation torque. As an alternative, the spacer may be installed on rods or tubes of the correct size.

The following displacements shall be applied:

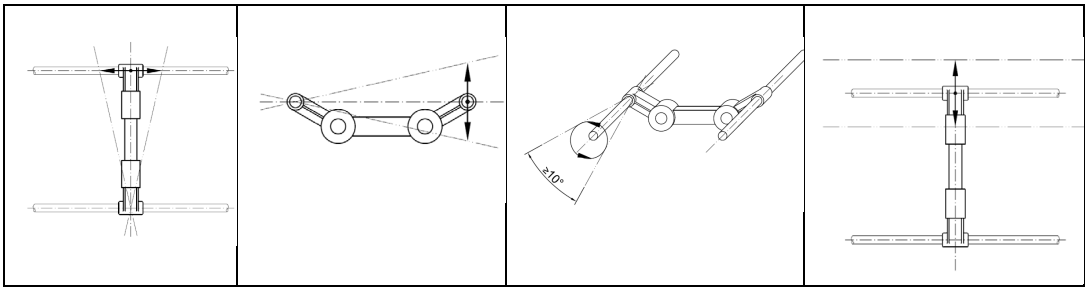
a) longitudinal displacement: horizontal, longitudinal, parallel movement of one sub conductor relative to the other(s) as measured by the deflection of the vertical longitudinal axis of the spacer arm from its position normal to the conductor;
b) vertical displacement: vertical movement of one sub conductor relative to the other(s) as measured by the vertical deflection of the horizontal axis of the spacer arm from its position normal to the conductor;
c) conical displacement: conical or angular movement of the spacer clamp on one sub-conductor as measured conically about the normal sub conductor axis;
d) transversal displacement: relative movement of two spacer clamps horizontally aligned perpendicular to the sub conductor axis, as measured by the increase and decrease of conductor separation.

The displacements shall be applied gradually for each pair of adjacent clamps.

Acceptance criteria:

The above movements or displacements shall be executed without slip or damage to sub conductors & spacer, as detected by visual examination after removal of the spacer.

Longitudinal displacement	Vertical displacement	Conical displacement	Transversal Displacement
Min: 25mm (p-p)	Min: 50mm (p-p)	Min: 10˚	Min: d(p-p)



Where "d" is the conductor diameter.

6.2.8.4. Characterization of the Elastic and Damping Properties

Stiffness and damping of each clamp that will undergo energy absorbing and simulated oscillation fatigue tests (Clauses 6.2.8.5 & 6.2.8.6 shall be obtained according to IEC 61854 clause 7.5.5 Method A using computer software. The hysteresis loop – recorded at 1.5 Hz - formed by displaying the force and arm angle of each clamp shall be recorded as initial values at all three temperatures (-5, 25 & 55)°C. Stiffness and damping as a function of frequency shall be also recorded on atleast five (05) no. of frequencies within the range of 5 ÷ 50 Hz at ambient temperature (vibration velocity 100 mm/s 0-peak).

At the end of energy absorbing and simulated oscillation fatigue tests (Clauses 6.2.8.5 & 6.2.8.6), stiffness and damping shall be obtained (at 1.5 Hz) on the same spacer damper arm/clamp that passed these tests. Vibration properties of samples (stiffness and phase difference) should not change more than 30% from their initial value. Furthermore, vibration properties of the fatigued spacer damper should be considered and bending strain-frequency graph of fatigued spacer damper shall be presented in a separate report as outlined in Clause 6.2.5.

6.2.8.5. Energy Absorbing Tests

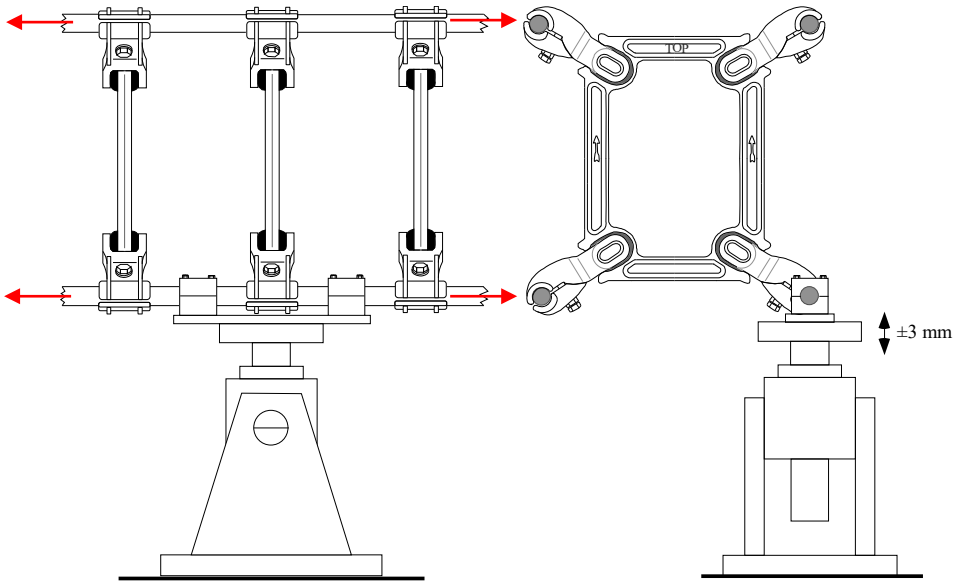
a. General

The spacer damper assembly for DRAKE Conductor shall be clamped to ACSR "DRAKE" conductor. During the tests, the axis of each spacer clamp shall be parallel to its initial static position by applying at least 22% of the U.T.S of the conductor tension on each conductor. The four sub-conductors shall be connected to suitable jokes at both extremities of the test span, in such a way that the desired longitudinal movement can be applied without releasing or varying the tensile load applied to the subconductors..

The spacer damper assembly shall withstand the tests without slipping on the conductors or failure of component parts. The clamps shall not be removed from the conductors, nor shall any bolts or cap screws be re-torqued until completion of the clamp slip tests.

b. Vertical Vibration

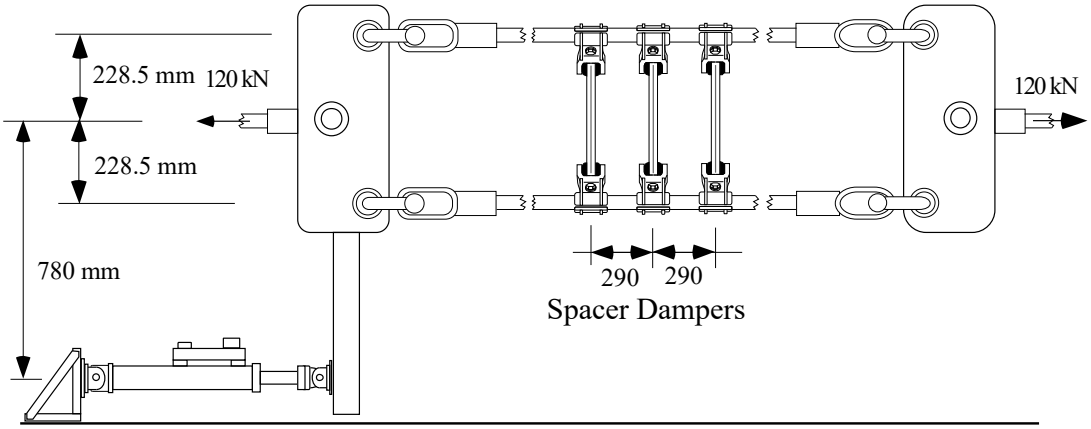
The spacer damper assembly shall be vibrated vertically from 5 to 50 Hz to determine if the spacer assembly has resonant frequencies within that range. If resonant frequencies are observed, the vertical vibration fatigue test shall be run at the highest resonant frequency found. If no resonant frequency between 5 and 50 Hz is observed, the test shall be run at a frequency from 20 to 30 Hz with amplitude of ±3 mm for 1,000,000 cycles. A check for resonance and the fatigue test shall be run for all the four clamps of three (03) samples fixed on conductor with inter-spacing of 290mm (the body of spacer assemblies shall be installed vertically). A possible test set up is shown in the sketch below:

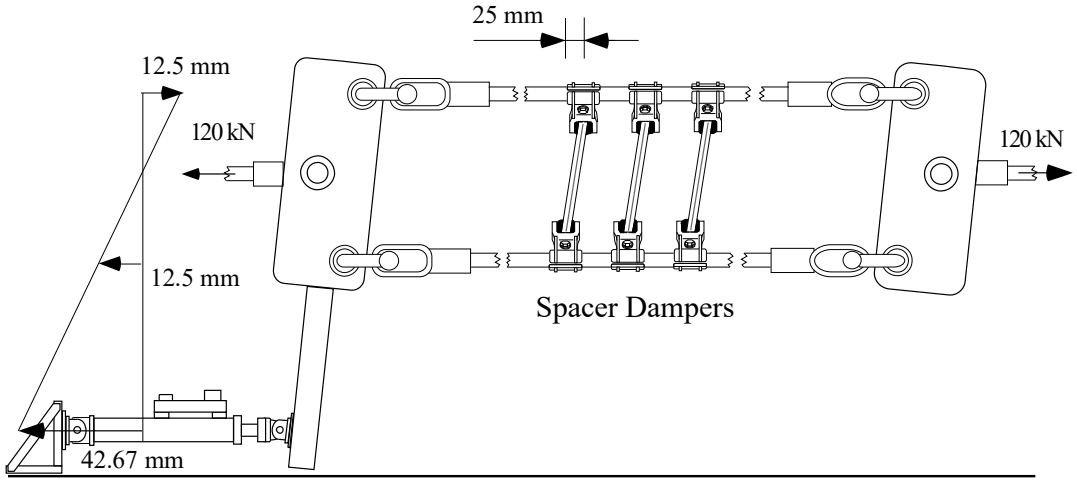


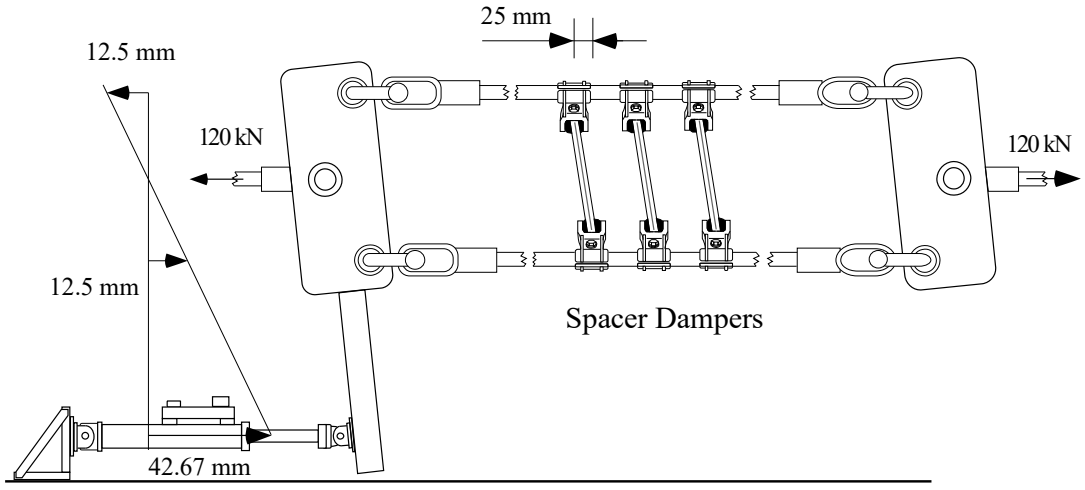
c. Longitudinal Displacement

The longitudinal displacement of the unrestrained conductor(s) shall be plus minus 25 mm. The longitudinal movement shall be parallel to the conductor(s) at a frequency not less than 2 Hz for 1,000,000 cycles with all the four clamps of the three (03) samples fixed on conductor.

A possible test set up is shown below. With this arrangement, the joke at one of the bundle extremities has been fitted with a rigid frame in such a way that forcing the frame at the lower extremity through an hydraulic actuator a horizontal movement of +/- 12.5 mm of the lower bundle sub-conductors and, contemporaneously, a horizontal movement of -/+ 12.5 mm of the upper bundle sub-conductors, is obtained. So the relative movement between upper and lower sub-conductors is +/- 25 mm, as required.







6.2.8.6. Simulated Oscillation Fatigue Test

Using the same spacer damper assemblies that were tested in vertical vibration and longitudinal displacement tests hereof, the spacer arm of each assembly cycled in clause 6.2.8.5 shall be tested for simulated oscillation test. With the body of the spacer damper restrained, the spacer arm shall be cycled in a plane at right angles to the normal conductor axis continuously for 1,000,000 cycles at not less than 4 Hz. The motion at each conductor clamp shall be in a path around the pivot point(s) of the arm

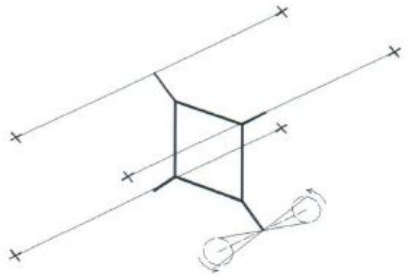
which:

a. Produces a single peak displacement resulting from the application of 300N static force. The displacement shall be determined at the beginning of the test and kept constant during the test, or

b. Produces at least 95 percent of the total stop to stop displacement. The clamp need not be installed on conductor. Endurance shall be assessed in accordance with the requirements of Clause 6.2.2 hereof.

Whichever motion produces the maximum displacement.

6.2.8.7. Conical Fatigue Test[1]



The same spacer damper arm/clamp used in test under clause 6.2.8.6 shall be tested for conical fatigue by installing the clamp on a cylindrical metallic bar of diameter D equal to the specified conductor dia and installing the other clamps on metallic bars of same diameter D, which have to be fixed to the ground as per following sketch in a suitable way in order to avoid vibrations and/or displacements. The tested clamp shall be excited through rotation so that a conical movement is achieved. The angle between the conical surface of the revolution generated by the cylindrical bar and the longitudinal axis of the clamp shall not be less than 2 degrees. The test shall be performed for 1 million cycles at frequency between 2 to 5 Hz. After the test, there should be no damage to any of the components or loosening of the bolt and if visible abrasion of elastomers noted during the test then abrasion resistance test shall be carried out to check its conformity to the manufacturer's specified minimum value of fatigued elastomers.

6.2.8.8. Bolt Torque Test

The four clamps of the spacer damper assembly shall be attached to the ACSR "DRAKE" conductor or to a bar of equivalent diameter. Torque shall be applied to the upper head of each break-away bolt. The head shall not break away at a value other than the Supplier's design installation torque plus or minus ten percent. The torque required to break away each upper head shall be recorded.

Also, at the manufacturer nominal installation torque the Belleville washer(s) should not have a permanent deflection greater than 10% of the recoverable deflection.

At a torque of twice of nominal design installation torque there shall be no failure of component parts. The torque shall then be recorded.

Records shall be made of the lower head withstand torque, failure torque, and the part(s) of the clamp assemblies that fail.

6.2.8.9. Simulated Short Circuit Current Test

[1] Sequence of performing conical fatigue test and simulated oscillation test can be changed by agreement between Engineer and the Manufacturer.

The spacer damper shall be tested to withstand three consecutive "shots" at a current of 50kA r.m.s. for four cycles (50 Hz) without permanent deformation or damage when installed at spacing up to a maximum of 76 meters, between spacers. The tension on all sub-conductors will be minimum 22% of the U.T.S of the conductor. The spacer damper shall be capable of restoring the sub-conductors to its original spacing without deformation or damage to spacer damper or conductor.

Mechanical testing will be considered in lieu of the above short-circuit test. The mechanical tests will be defined by mutual agreement between the Supplier and the Engineer. After the test, there shall be no indication of failure of any component or any permanent deformation from the original geometric configuration.

Suitable devices which are able to apply compressive forces (directed toward the center of the conductor bundle) and tensile forces (directed away from the center of the conductor bundle) to all spacer clamps simultaneously, in a manner representative of actual site conditions, shall be used. No restraint should be applied by this device in the direction orthogonal to the compression (or tension) forces.

a) **Compression**

The compressive forces shall be gradually increased until they reach the value 1675 kg calculated according to IEC 61854 Annex-B. At this value the forces shall be held constant for 60 sec. and then removed. The test shall be executed twice; the first one with the spacer in its normal position and the second one with one clamp displaced longitudinally by an amount of 12.5mm, with reference to the other clamp(s).

b) **Tension**

Following compressive forces, tensile forces shall be applied. These forces shall be gradually increased until they reach the specified value at which they shall be maintained for 60 sec. The value of the tensile forces shall be taken as 50% of the corresponding compressive forces.

6.2.8.10. Corona and RIV Test

The corona extinction voltage for the spacer damper shall be determined visually in a virtually dark laboratory. The corona extinction voltage is the voltage at which the spacer damper is free of all visual corona.

The spacer damper assembly shall be installed on section of ACSR “DRAKE” conductor or bar not larger than 28.14 mm diameter. The conductor or bar shall be arranged as a quad bundle.

The spacer damper assembly shall be subjected to a voltage to determine that the corona extinction voltage level is not less than 346 kV line-to-ground. The ground plane shall be a maximum of 4 meters from the assembly.

The exposure shall be made with an applied voltage and the laboratory virtually dark. There shall be no evidence of corona on the spacer damper.

Digital camera shall be used to satisfy the condition of corona.

The RIV test shall be performed in accordance with IEC 60437 with 60 dB μV/m at 0.5 MHz measuring frequency as the limiting value of radio interference characteristic.

Corona inception and extinction observation will be carried out both for negative and positive corona

6.2.8.11. Electrical Resistance Test

This test shall be performed in accordance with clause 6.7.2 of IEC 61854, however the resistance between two adjacent clamps shall be more than 10 kΩ. To avoid problems caused by capacitive charging of the spacer damper components in service, the resistance between two adjacent clamps shall be less than 10 MΩ. The resistance of elastomer shall be indicated on the spacer damper drawings.

The electrical resistance of the elastomeric elements shall be determined between any couple of conductors by the application of 100 V_{rms} (±10%) at 50Hz and the resistance determined from V_{rms}/I_{rms}. The elastomeric elements and the clamp liners shall be free from moisture or any liquid during assembly when testing is performed.

6.2.8.12. Elastomer Tests

Typical properties and values of the elastomer or other energy absorbing assembly shall be specified by the manufacturer and shall be provided along the drawing/data submitted. The tests shall be performed on samples taken from elastomeric components. The following tests on elastomers shall be performed as per relevant ASTM Standards to ascertain the requirements specified in Clause 6.2.2:

(i) Specific Gravity and Density Test (ASTM D 792).

(ii) Shore A Hardness Test (ASTM D 2240).

(iii) Electrical Resistance Test (IEC 61854).

(iv) Ultraviolet Resistance Test (ASTM D750 + (ASTM G 154 or ASTM G 155 depending on availability of test setup and approval of the Engineer).

(v) Ozone Resistance Test:
Non-metallic spacer damper parts shall resist Ozone attack and shall show no sign of damage after the following Ozone test as per ASTM D-1149 modified as follows:

Three finished full size specimens, mounted in their normal housing will be placed in an Ozone chamber for 72 hours at a temperature of 60°C. The concentration of Ozone shall be 50 parts per 100 million. One specimen shall be unstressed, and the second specimen will be subjected to the maximum stress.

No cracks shall be visible under 7 × Magnification.

(vi) Temperature endurance test:
This test is aimed to check permanent change in nonmetallic part with changing temperature. Three (03) clamps first should pass tests under Clause 6.2.8.4 at ambient temperature, then cool to -10˚C and maintain it for 60min. After that, warm the samples to 100˚C for 60min. Then test under Clause 6.2.8.4 shall be

performed again at ambient temperature and compare vibration properties of the samples before and after performing this test. Variation in stiffness and phase difference between force and displacement shall not be more than 5%.

(vii) Temperature sensitivity test:
This test is aimed to see damping performance of energy absorbing assembly in different temperatures. Test under clause 6.2.8.3 should be performed on three (03) clamps, in ambient temperature, -5˚C and +55˚C. Vibration properties of sample in high temperature and low temperature should not change more than 30% from their values in ambient temperature. Vibration properties of hot and cold spacer damper should be considered and bending strain-frequency graph and their acceptance criteria should be presented.

(viii) Tension and Elongation Test (ASTM 412 C).

(ix) Tear Resistance Test (ASTM D 624 B).

(x) Compression Set at 70h, 20˚C-100˚C-0˚C (ASTM D 395 B).

(xi) Rebound Resilience at 20˚C-100˚C-0˚C.

(xii) Air-Oven Deterioration Test 72h, 70˚C (ASTM D 573).

(xiii) Deterioration in Oils 72h, 70˚C (ASTM D 471).

(xiv) Water Immersion Test (ASTM D 471).

(xv) Abrasion test (ASTM D 5963).

The values for these tests shall fulfill the requirements specified in the Clause 6.2.2 & 6.2.4 and those guaranteed by the manufacturer.

6.2.8.13. Galvanizing Tests:

These tests shall be carried out on all ferrous parts complying with the following requirements:

a. Weight /Thickness of zinc coating by stripping method or by meter
b. Uniformity of zinc coating
c. Adherence of zinc coating

These tests shall be performed in accordance with ASTM A123 & A153.

6.2.9. SAMPLE TESTS

Sample tests shall be made on all subsequent offered lots to verify the quality and workmanship. The number of samples shall be selected as per BS 3288-1 for the following tests.

(i) Visual examination
(ii) Verification of dimensions

(iii) Galvanizing tests on ferrous parts
(iv) Clamp Slippage Test at Ambient Temperature
(v) Bolt Torque Test
(vi) Flexibility Test
(vii) Characterization of the elastic and damping properties
(viii) Electrical Resistance Test
(ix) Simulated Short Circuit Test

(i) Visual Examination:
The tests shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant drawing. Any part missing.
Finish	Galvanizing not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

(ii) Verification of Dimensions:
The binding dimensions of the spacer dampers shall be measured as shown on the relevant approved drawings.

(iii) Galvanizing Tests:
These tests shall be carried out on all ferrous parts complying with the following requirements:

d. Weight /Thickness of zinc coating by stripping method or by meter
e. Uniformity of zinc coating
f. Adherence of zinc coating

These tests shall be performed in accordance with ASTM A123 & A153.

(iv) Clamp Slippage Tests at Ambient Temperature:
This test shall be performed in accordance with Clause 6.2.8.2.

(v) Bolt Torque Test:
This test shall be performed in accordance with Clause 6.2.8.8.

(vi) Flexibility Test:
This test shall be performed in accordance with Clause 6.2.8.3.

(vii) Characterization of the elastic and damping properties:
This test shall be performed in accordance with clause 6.2.8.4. The torsional stiffness shall not differ by more than ±20% and the ratio of damping constant to torsional stiffness shall not be lower than 20% from the values declared by the manufacturer or the values obtained during qualification tests.

(viii) Electrical Resistance Test:
This test shall be performed in accordance with clause 6.2.8.11.

(ix) Simulated Short Circuit Test:

This test shall be performed in accordance with clause 6.2.8.9.

6.3. SPACERS FOR CONDUCTOR JUMPERS

6.3.1. PHYSICAL REQUIREMENTS

The spacers shall be designed for use on 457mm quad-bundle 795 KCM 26/7 ACSR "DRAKE" conductor. Clamps of the spacer, which are fastened with bolts, shall be provided with breakaway heads or caps and suitable washers. The spacers shall be capable of being installed and removed from energized lines by means of hot-line tools.

Clamping bolts shall be M16 aluminum alloy or minimum M12 stainless steel with a break-away type shear head bolt or galvanized steel equipped with a break-away type cap made of zinc alloy. The torque required to break away the upper head from the lower head shall be within a tolerance of plus or minus ten percent (10%) of the Supplier's design value.

The spacer damper shall be designed to withstand the electromagnetic forces resulting from short-circuit currents of 50,000 Amps. r.m.s. symmetrical for 4 cycles (50 Hz).

6.3.2. QUALIFICATION TESTS REQUIREMENTS

The following tests shall be performed by the Supplier to establish the characteristics of the spacers when installed on the conductor and to assure compliance with all requirements specified.

Certified copies of type test reports if already carried out on the identical spacers including test data which show that the spacer assemblies meet all the requirements of these specifications shall be submitted. The performance of tests must have been completed and test data approved before any of the spacers are shipped.

(i) Bolt Torque Test

The four clamps of the spacer assembly shall be attached to the ACSR Drake conductor or to a bar of equivalent diameter. Torque shall be applied to the upper head of each break-away bolt. The head shall not break away at a value other than the Supplier's design installation torque plus or minus ten percent. The torque required to break away each upper head shall be recorded.

At a torque of twice of nominal design installation torque there shall be no failure of component parts. The torque shall then be recorded.

Records shall be made of the lower head withstand torque, failure torque, and the part(s) of the clamp assemblies that fail.

(ii) Simulated Short Circuit Current Test

The spacer shall be tested to withstand three consecutive "shots" at a current of 50,000 Amperes r.m.s. for four cycles (50 Hz) without permanent deformation or damage when installed at spacing up to a maximum of 76 meters, between spacers. The tension on all sub-conductors will be minimum 10% of the U.T.S of the conductor. The spacer damper shall be capable of restoring the sub-conductors to its original spacing without deformation or damage to spacer damper or conductor.

Mechanical testing will be considered in lieu of the above short-circuit test. The mechanical tests will be defined by mutual agreement between the Supplier and the Engineer. After the test, there shall be no indication of failure of any component or any permanent deformation from the original geometric configuration.

a) **Compression**

The compressive forces shall be gradually increased until they reach the value 1075 kg calculated according to IEC 61854 Annex-B. At this value the forces shall be held constant for 60 sec. and then removed.

b) **Tension**

Following compressive forces, tensile forces shall be applied. These forces shall be gradually increased until they reach the specified value at which they shall be maintained for 60 sec. The value of the tensile forces shall be taken as 50% of the corresponding compressive forces.

(iii) Corona and RIV Test

The corona extinction voltage for the spacer shall be determined visually in a virtually dark laboratory. The corona extinction voltage is the voltage at which the spacer is free of all visual corona.

The spacer assembly shall be installed on a section of ACSR Drake conductor or bar not larger than 28.14 mm diameter. The conductor or bar shall be arranged as a quad bundle.

The spacer assembly shall be subjected to a voltage to determine that the corona extinction voltage level is not less than 346 kV line-to-ground. The ground plane shall be a maximum of 4 meters from the assembly.

The exposure shall be made with an applied voltage and the laboratory virtually dark. There shall be no evidence of corona on the spacer damper.

Digital camera shall be used to satisfy the condition of corona.

The RIV test shall be performed in accordance with IEC 60437 with 60 dB μV/m at 0.5 MHz measuring frequency as the limiting value of radio interference characteristic.

Corona inception and extinction observation will be carried out both for negative and positive corona.

6.3.3. SAMPLE TESTS

Sample tests shall be made to verify the quality and workmanship. The number of samples shall be selected as per BS 3288-1 for the following tests.

(i) Visual examination
(ii) Verification of dimensions
(iii) Galvanizing tests on ferrous parts
(iv) Bolt Torque Test

(v) Simulated Short Circuit Test

(i) Visual Examination:

The tests shall be examined visually for the following defects:

Examination	Defects
Material	Not as specified in relevant clauses.
Construction	Not of the shape given in relevant Drawing. Any part missing.
Finish	Galvanizing not proper. Presence of burrs, black and bare spots, dross and projections, which will interfere with proper use of the articles.

(ii) Verification of Dimensions:

The binding dimensions of the spacer shall be measured as shown on the relevant approved drawings.

(iii) Galvanizing Tests:

These tests shall be carried out on all ferrous parts complying with the following requirements:

a. Weight of zinc coating
b. Uniformity of zinc coating
c. Adherence of zinc coating
d. Purity of zinc coating (99.995%)

These tests shall be performed in accordance with ASTM A123 & A153.

(iv) Bolt Torque Test:

This test shall be performed in accordance with Clause 6.2.8.8.

(v) Simulated Short Circuit Test:

This test shall be performed in accordance with clause 6.2.8.9.

7. GROUNDING MATERIAL

This specification specifies the minimum technical requirements for design, manufacture, inspection and testing of grounding material to be used on 500kV double circuit quad bundle transmission line.

7.1. GROUNDING RODS

The ground rods shall be copper-weld/copper covered high strength carbon steel of circular cross-section 16 mm in diameter and 3.0 meters long. Each ground rod shall have a conical machined point at one end and shall be chamfered at the other end for ease in driving in the soil. The copper weld/copper cover shall be of uniform thickness not less than 0.38 mm for copper weld and 0.45 mm for copper cover. The copper covering shall be applied by either the molten-welded or copper bonded process (electro-deposited), giving a moisture proof seal between copper and core. The Contractor shall clearly state the process of manufacture. The length, diameter and copper thickness shall be marked on the rod. The applicable standard for material, fabrication and testing shall be ANSI/UL467. The steel used in the manufacturing of earth rods shall have the following characteristics:

Tensile Strength	:	41-56 kg/mm^2
Yield Point (min)	:	25 kg/mm^2
Elongation (min)	:	As per standard (20% in 200mm gauge length)

7.2. SAMPLE TESTS

Sample tests shall be made to verify the quality and workmanship of ground rods as per following procedure:

Individual rods shall be visually examined for the defects given below:

Examination	**Defects**
Construction	- Not of shape shown in drawing. - Not of correct material. - Any crack on the material
Finish	Copper thickness not proper, presence of burrs, black or base spots, and projections which will interfere with the proper use of the article. Corner edges not rounded.
Marking	Missing, not legible, incomplete or not permanent.

(i) Visual Examination and Verification of Dimensions and Material:
Conformity of manufacturing process, shape, coating, surface finish, markings, dimensions and material with the contract drawings and technical provisions will be ensured.

(ii) Bending Test:

The earth rod shall be subjected to a cold bending test at ambient temperature. The rod shall be held in a suitable rigid clamp or vice and the free end bent by applying a force perpendicular to the rod at a distance of 40 times rod diameter from the clamping device. The normal force shall be applied until a permanent angular bent of 30 degree is achieved by the rod. The rod shall be capable of withstanding the cold-bent test without any evidence of pits, cracking, or separation of copper from steel on the surface of the bent portion.

(iii) Tensile Test:

The steel shall be tested for mechanical strength and elongation mentioned in Clause 7.1.

(iv) Adherence Test:

The earth rod shall be subjected to adherence test to determine the bondage between copper and steel surfaces. A half meter length of rod with one end cut to a 45 degree point. This end shall be driven between two steel clamping jaws of a vice set at one millimeter less than the diameter of a vice set at one millimeter less than the diameter of the rod so as to shear off sufficient metal to expose the bond between the jacket and steel core. There shall be no evidence of any separation.

(v) Verification of Copper Thickness

Thickness of copper covering on the steel rod will be verified and reported.

(vi) Sample, Acceptance and Rejection:

The earth rod shall be divided into lots containing up to 500 units each. A sample of 20 rods shall be drawn at random from each lot.

The selected samples shall be subjected to visual examination and verification of dimensions. If the number of defective units is two the lot shall be accepted, if the number of defective units is more than three the lot shall be rejected. If the number of defective units is three, another sample of 25 units shall be selected at random and subjected to tests. If the number of defective units is again three or more, the lot shall be rejected. If the number of defective units is three or less the lot shall be accepted.

Three random samples shall be selected from a lot of 500; each rod shall be subjected to tensile, bending and adherence tests.

If one rod from any group of three units selected fails to meet the requirement, another group of three rods shall be selected at random. If any unit in the second group fails the test, the lot shall be rejected.

7.3. GROUNDING CONNECTORS FOR GROUND RODS

The connector for attaching ground wire to ground rods shall be bronze or high strength copper alloy. The clamps shall be as shown on the Specification Drawings.

The connector for attaching ground wire to tower stub angle shall be hot dipped galvanized steel. The clamps shall be secured by one 16 mm diameter steel bolt.
The connectors shall be tested for mechanical strength test specified in ANSI/UL467.

8. OPTICAL FIBER EQUIPMENT

This section of Technical Provisions specifies technical requirements for design, engineering, manufacture, inspection, testing and performance of Optical Ground Wire (OPGW). Optical fiber equipment shall conform to the requirements of NTDC Specifications appended herewith as Appendix-III: SPECIFICATION FOR OPGW & JOINT BOXES.:

APPENDIX-I: DRAFT SPECIFICATION P-8B FOR GLASS INSULATORS 19-10-20 - SHORT STRING POWER ARC

APPENDIX-II-: TLMS-8A – NON CERAMIC COMPOSITE INSULATORS FOR OVERHEAD TRANSMISSION LINES 132KV/220KV/500KV

APPENDIX-III: SPECIFICATION FOR OPGW & JOINT BOXES

SPECIFICATION P-8B: 2020

DRAFT

TOUGHENED GLASS
DISC INSULATORS

(BALL & SOCKET AND CLEVIS & TONGUE COUPLING)

(REVISION – 0)

DESIGN (T/LINES) DEPARTMENT

NATIONAL TRANSMISSION AND DESPATCH COMPANY LIMITED (NTDC)

Table of Contents

PRINTING CHRONOLOGY
Original Specification (First version) September 2020.

TOUGHENED GLASS DISC INSULATORS

0 FOREWORD

0.1 This specification has been prepared by Design (T/Lines) Department, NTDC and lays down the requirements for disc type glass insulators with ball & socket and clevis & tongue coupling for use in NTDC transmission system and DISCOs located in different severe environmental & service conditions from high altitude, icy mountainous & large temperature fluctuations in Northern areas of Pakistan to hot & heavily polluted Southern areas and Marine/corrosive environment prevailing along coastal lines in Southern areas of Pakistan.

0.2 This specification is comprehensive and should facilitate procurement of appropriate quality material. It does not include provisions of Contract. This specification shall also be read in conjunction with NTDC contract/order of the project, whichever is applicable.

0.3 This edition is the original version of specification.

0.4 This specification is mainly based on following international standards in respect of manufacturing and testing requirements. If however, the requirements mentioned herein differ from those indicated in the relevant international standards, the requirements indicated herein shall prevail.

0.5 This specification is subject to revision as and when required.

APPLICABLE CODES AND STANDARDS

The latest revision and amendments of codes and standard mentioned below shall be applicable for all type of toughened glass disc insulators to be supplied to NTDC.

a. IEC 60060-1 High-voltage test techniques – General definitions and test requirements

b. IEC 60060-2 High-voltage test techniques – Measuring Systems

c. IEC 60120 Dimension of ball and socket coupling of String Insulator Units

d. IEC 60305 Insulators for overhead lines with a nominal voltage above 1000V. Ceramic or Glass Insulators units for A. C. System. Characteristics of Insulator Units of the cap and pin type

e. IEC 60372 Locking devices for ball and socket coupling of string insulator units – Dimensions and Tests

f. IEC 60383-1 Insulators for overhead lines with a nominal voltage above 1000V- Part 1. Ceramic or Glass Insulators units for A. C. System. Definitions, tests methods and acceptance criteria

g. IEC 60383-2 Insulators for overhead lines with a nominal voltage above 1000V- Part 2. Insulator string and insulator sets for A. C. System. Definitions, tests methods and acceptance criteria

h. IEC 60507 Artificial Pollution Tests on High Voltage Insulators to be used on A.C systems

i. IEC 60575 Thermal – mechanical performance tests and mechanical performance tests on string insulator units

j. IEC 61211 Insulators of Ceramic material or Glass for overhead lines- with a nominal voltage greater than 1000V-— Impulse puncture testing in air

k. IEC 61325 Insulators for overhead lines with a nominal voltage above 1000 V — Ceramic or glass insulator units for d.c. systems — Definitions, test methods and acceptance criteria

l.	IEC 61467	Insulators for overhead lines- Insulator strings and sets for lines with a nominal voltage greater than 1000V – A. C. power arc tests
m.	ANSI C29.1	Test Methods for Electrical Power Insulators
n.	ANSI C29.2 B	Insulators, Wet Process Porcelain and Toughened Glass, Suspension Type
o.	ASTM C 151M	Standard Test Method for Autoclave Expansion of Hydraulic Cement
p.	ASTM A153	Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
q.	EN 14179-1	Glass in building — Heat soaked thermally toughened soda lime silicate safety glass
r.	EN 14647	Calcium aluminate cement — Composition, specifications and conformity criteria

1. SCOPE

These specifications specifies the minimum technical requirement for design, engineering, manufacture, inspection, testing and performance of the toughened glass disc insulators intended to be used in the NTDC Transmission System and DISCOs.

2. DEFINITIONS

2.1 Flashover

Flashover is a discharge through air, taking the form of an arc or a spark or of several arcs or sparks, connecting the parts of an insulator which normally have the operating voltage between them.

Note: The term Flashover used here includes a flashover across the insulators surface as well.

2.2 Leakage Distance

The leakage distance of an insulator is the sum of the shortest distances measured along the insulating surface between the conductive parts.

2.3 Lot

A quantity of insulators manufactured or produced under conditions which are presumed uniform and offered for acceptance.

2.4 Mechanical Impact Strength

The mechanical impact strength of an insulator is the impact, which the insulator can withstand without damage, under the specified conditions.

2.5 Puncture

Puncture is a local or total destruction of the insulating material caused by a discharge passing through it.

Note: A fragment breaking away from the rim of the shed or damage to the insulator due to heat of a surface discharge shall not be considered as puncture.

2.6 Radio – Influence Voltage

The radio influence voltage of an insulator is the radio frequency voltage produced under specified conditions, by the application of an alternating voltage of 50 Hz ± 5%.

2.7 Sample

Items selected from the lot to be subjected to the acceptance tests.

2.8 Simple Random Sample

A sample of n item taken from a population of N items in such a way that all possible combinations of n items have the same probability of being chosen.

2.9 Standard Atmospheric Conditions

Standard atmospheric conditions for the purpose of this specification are:

Ambient Temperature: -10 ºC to +55 ºC

Barometric Pressure 1014 millibars, 760 mm (29.9 inches) of mercury.

Humidity and other atmospheric conditions shall be as specified in the Contract or Order of the project, as applicable.

2.10 Test Specimen

A test specimen is an insulator which is representative of the product being tested, it is specimen that is undamaged in any way which would influence the result of the test.

2.11 Dry or Wet One Minute Power Frequency Test Voltage

The power frequency voltage which the disc insulator can withstand for one minute wet or dry under the conditions prescribed without flashover or puncture.

2.12 24 Hours Mechanical Test Load of Disc Insulator

This is a mechanical load which the disc insulator can withstand for 24 hours, under the conditions prescribed without breakage or shattering or puncture.

2.13 Short Time Electro-Mechanical Breaking Load of Disc Insulator

This is the mechanical load which, under the prescribed conditions, causes puncture or breakage of any part of the disc type insulator unit.

2.14 Mechanical Breaking Load

This is the mechanical load which, under the prescribed conditions, causes separation of metal parts.

2.15 Puncture Voltage

The puncture voltage of disc insulator is the voltage which, under the prescribed conditions, causes puncture.

2.16 Clevis and tongue coupling

Coupling which consists of a clevis, tongue and a coupling pin.

2.17 Clevis

The female part of a clevis and tongue coupling with a U-shaped opening into which the tongue coupling can be fitted. It contains two holes through which the coupling pin may pass to couple the two components.

2.18 Tongue

The male part of a clevis and tongue coupling with a tongue-shaped extremity which fits into the U-shaped opening of the clevis and which contains a hole through which the coupling pin may be passed.

2.19 Coupling pin

The rigid pin which passes through the holes in the clevis and tongue to couple them together. On one end, the coupling pin has a stud head; on the other, a security device (e.g. split pin) is placed to hold the pin in its place.

2.20 Salt Deposit Density (SDD)

Amount of sodium chloride in an artificial deposit on a given surface of the insulator (metal parts and assembling materials are not to be included in this surface) divided by the area of this surface.

2.21 Equivalent Salt Deposit Density (ESDD)

Amount of sodium chloride (NaCl) that, when dissolved in demineralized water, gives the same volume conductivity as that of the natural deposit removed from a given surface of the insulator divided by the area of this surface, generally expressed in mg/cm^2.

2.22 Non-Soluble Deposit Density (NSDD)

Amount of non-soluble residue removed from a given surface of the insulator, divided by the area of this surface.

2.23 Pollution Layer

A conducting electrolytic layer on the insulator surface, composed of salt plus inert materials.

3. DESIGN AND CONSTRUCTION REQUIREMENTS

3.1 General

3.1.1 The insulators shall have insulating part made from toughened glass and shall meet or exceed the requirements of this Specification and shall be suitable for use in all areas of NTDC system. The text and figures supplement each other and shall be considered part of this specification.

Ball and socket disc insulators shall comply with designation as defined in Clauses 3.3 & 5.1 and shall have standard couplings and locking devices as specified in this specification.

Tongue and clevis disc insulators shall comply with designation defined in Clause 5.2 of this specification. Each unit shall be supplied complete with a coupling pin and one (1) of stainless steel humpback split pin as specified in this specification.

3.1.2 The Manufacturers design drawings shall show the outline of the toughened glass insulators together with all the pertinent dimensions. Any variation in these dimensions due to manufacturing tolerance shall be indicated on the drawings. The drawings shall have minimum of two views with an appropriate scale. The following information shall be provided on the drawings:

a. Drawing number and revision
b. Date of issue
c. Scale
d. Type and/or Catalogue number
e. Principal dimensions with manufacturing Tolerances
f. Skirt spacing with tolerances
g. Surface area of Top and bottom glass disc body (separately)
h. Height of Glass Shell
i. Electrical and Mechanical (E & M) strength and Electromechanical Failing Load.
j. Tension proof load

k. Impact Strength
l. Electrical Data
   - Dry Power Frequency withstand voltage (KV)
   - Wet Power Frequency withstand voltage (KV)
   - Dry Lightning Impulse withstand voltage (KV)
   - Minimum Power Frequency Puncture Voltage (KV)
   - Critical impulse flashover-Positive
   - Critical impulse flashover-Negative
   - Power Frequency electric arc voltage (s/KA)
   - Radio influence voltage 1 MHz (μ V)
m. Minimum Creepage Distance with positive tolerance
n. Minimum dry arcing distance with positive tolerance
o. Metal hardware component standard and grade
p. Net Weight of insulator unit
q. Zinc Coating Thickness on ferrous (cap & pin) parts
r. Cap & pin Material
s. List of material
t. Connecting length with tolerance
u. All Markings

3.1.3 The Insulator shall be capable to withstand the mechanical stresses which can occur during handling, transportation and installation temperature as low as -20ºC, in addition to the mechanical stresses which can occur during the life time of the overhead transmission lines at temperature from -20ºC to 93ºC.

3.2 Design Criteria

3.2.1 The toughened glass insulators shall be designed to withstand all prevalent environmental conditions including temperature fluctuation between days & nights as specified in the contract/order.

3.2.2 The toughened glass with ball and socket coupling or clevis & tongue arrangement shall be designed to withstand water jet pressure of 3800 kPa as per Clause 8.2 of IEEE 957.

3.2.3 Clevis & tongue fittings or ball & socket coupling of insulators shall be ANSI or IEC compactable, and shall be securely connected to insulators.

3.2.4 The metal parts and the toughened glass parts shall be moveable in relation to each other in order to avoid large mechanical stress due to difference in coefficient thermal expansion of the metallic parts, cement, and toughened glass materials. Thus the metal cap shall move up and down, in an elastic manner under the external tension load on the sloping surface of the adjacent cement. The metal pin shall act in the same manner as stipulated in IEC 60575 Clause A2.1.

3.2.5 Care shall be taken when providing the required leakage distance to avoid designs in which skirts are mechanically fragile.

3.2.6 The metal parts shall be designed to transmit the mechanical stresses to the toughened glass by compression and to develop maximum and uniform mechanical strength of insulators. In general, the contours of the metal and toughened glass parts shall be such as to eliminate area of high electrical stress concentrations. All surfaces of metal parts shall be smooth with no projecting points or irregularities which may cause RIV and Corona.

3.2.7 The design of the cap and toughened glass shell shall be straight head type and cross-section drawing should be submitted with the Bid, which shows the straight head design. The insulators inclusive of the ball and socket / clevis and tongue fittings shall be of design

suitable for use with hardware fittings of NTDC approved hardware manufacturers conforming to relevant Standards.

3.2.8 The design of the insulators shall be such that the shell shall not engage directly with hard metal. The design shall also be such that when units are coupled together there shall be no contact between the shell of one unit and metal of the next adjacent unit.

3.3 Electrical and Mechanical Ratings

The Fog type Toughened Glass suspension insulators shall have the minimum electrical and mechanical rating as mentioned below:

Sr. No.	Description	E & M Strength					
		240kN	210kN	160kN	120kN	100kN	80kN
1.	Tension Proof Load	50% of specified Electrical and Mechanical Strength					
2.	(a) Power Frequency Withstand Voltage						
	i. Dry, kV - one minute	90	90	90	85	85	85
	ii. Wet, kV - one minute	50	50	50	45	45	45
	(b) Dry Lightning Impulse (1.2 x 50 Microsecond wave) Withstand Voltage						
	i. Positive, kV	140	140	140	125	125	125
	ii. Negative, kV	140	140	140	125	125	125
3.	Power Frequency Puncture Voltage, kV	130	130	130	130	130	130
4.	Radio Influence Voltage						
	(a) Test Voltage to ground, kV	10	10	10	10	10	10
	(b) Max. RIV at 1000kHz, µV	50	50	50	50	50	50
5.	Impact Strength, N-m	11.5	11.5	11.5	7.0	7.0	7.0
6.	Residual Strength after Maximum loading	70% of rated Electrical and Mechanical Strength					

4. MATERIAL AND FABRICATION

All raw materials to be used in the manufacturing process of toughened glass insulators shall be subject to strict raw material quality control and to different stage testing/quality control during all manufacturing stage.

All finish insulator shells shall be sound and free from any tiny inclusion or any latent defects that might adversely affect the insulator performance in the field or can lead to shattering.

4.1 Toughened Glass Shell

The entire glass surface of insulator shell shall have uniform thickness and shall be uniformly toughened, smooth, very well centered and free from imperfections as specified in clause 5.2 of ANSI C29.2 B.

The toughened glass used shall have no surface defects such as folds, blowholes, prejudicial to satisfactory performance during service and there shall be no bubble in the glass surface greater than 5mm in diameter as specified in clause 27.2 of IEC 60383-1.

4.2 Portland cement or hot cured Alumina cement shall be used as a bonding agent between toughened glass and metal parts. Sulfur based cement shall not be used.

If Portland cement is used in the assembly of the insulators, it shall have an autoclave expansion limit of less than 0.12 percent when tested in accordance with ASTM C151-84,

Test Method for Autoclave Expansion of Portland Cement as specified in Clause 8.2.10 of ANSI C29.2 B.

After curing (and preferably also before curing), every insulator unit shall be subjected to a thorough wet cleaning process to remove any additional or unwanted cement residues. Excessive cement deposits on the toughened glass shell or between the insulator cap and toughened glass body will lead to rejection of the offered insulators.

Cement used in manufacturing of the insulators shall neither be subjected to cement growth nor to be the cause of fracture by expansion or loosening by contraction. The cement shall not give rise to chemical reaction with metal fittings and its thickness shall be as small and uniform as possible. Proper finish & special care shall be taken to correctly center and locate individual parts during cementing.

4.3 **Metal parts**

4.3.1 Caps

Caps shall be made of best commercial grade malleable iron, ductile iron or steel as per clause 5.3 of ANSI C29.2 B. Ferrous parts, other than stainless steel shall be hot dip galvanized in accordance with Clause 6 of this Specification. The ferrous material shall conform to applicable ATSM Standards:

1) Malleable cast iron - ASTM standard A47 or A220
2) Ductile (spheroidal) cast iron - ASTM standard A536, Grade 60-40-18 or 65-45-12.

These shall be free from cracks, shrinks, air holes, burrs or rough edges. The cap shall be circular with the inner and outer surfaces concentric and of such design that they will not yield or distort under the specified mechanical loading in such a manner as to add undue stresses to the shell.

4.3.2 Pins

The pin shall be made of forged steel and shall be free from laps, folds, burrs or rough edges. All bearing surfaces shall be smooth and uniform so as to distribute the stresses evenly. The pins shall be of such a design that they will not yield or distort under the specified mechanical loading in such a manner as to add undue stresses to the shells. The steel forging shall meet the mechanical properties of ASTM A668.

4.3.3 Locking Devices

Standard split pin locking device shall be used. The split pins shall show no cracks by visual inspection when the prongs of the key are opened to 180° and then returned to the original position.

The material of split pin shall be standard quality stainless steel or bronze as specified in clause 5.4.1 of ANSI C29.2 B conforming to ANSI 304 and shall be resistant to internal corrosion.

Steel parts shall exhibit a minimum elongation at room temperature of 16% when tested in accordance with ASTM A370 (standard 50 mm gauge length).

Standard dimensions and shape of split pins locking devices of ball & socket shall conform to IEC 60372.

4.4 Fabrication

In addition to recommended excellent selection of raw material, controlled weighing, temperature stability of the furnace, uniform thickness of molded shell and multi thermal shocks of toughened discs throughout, the following criteria & requirement should be fulfilled:

a. The contours of the metal and glass parts shall be such as to eliminate areas of high electrical stress concentrations.
b. The axial, angular and radial displacement of the insulator and their verification shall be in accordance with Clause 21 of IEC 60383-1.
c. To inhibit the accelerated corrosion of the Toughened Glass Insulator pin due to leakage current, a corrosion intercepting zinc sleeve fused to the pin shall be provided at the point where steel pin emerges from the cement. The protective zinc sleeve shall be casted around the pin at the interface between the pin and the cement. The manufacturer shall provide certification which indicates the purity of the zinc used to make the collars as specified in IEC 61325. The sleeve shall be formed from zinc having a purity of not less than 99.99%. The bonded area of the sleeve shall be a minimum of 80 % of the sleeve/pin interfacial area. The exposed part of the sleeve shall have a mass of at least 5 g approximately 50 % of the total length of the sleeve shall be exposed. The bonding and adherence between zinc sleeve and pin shall remain intact upto 65% of its rated M&E strength. The zinc sleeve shall meet the requirements specified in Clause 35 of IEC 61325.
d. The manufacturer shall provide certification which indicates the purity of the zinc used to make the zinc sleeve.
e. Ball and socket insulators shall be furnished with a positive locking device of split cotter key type. Cotter keys shall be humped to maintain the key in locked and unlocked positions and shall have prongs spread to prevent complete withdrawal from the socket as stipulated in clause 5.4.2 of ANSI C29.2 B.
   Clevis insulators shall be furnished with a hump-type cotter key which shall prevent the cotter bolt from unintentionally being pulled out of the insulator cap during normal handling and use 5.4.3 of ANSI C29.2 B.
   The design of the keys shall be such that their engagement and disengagement can be achieved with the use of standard transmission hot line maintenance tools without excessive force required.
f. Cap Mounting
   The cap and pin shall be cemented on the glass with load distribution evenly throughout the glass. No Plastic, rubber or similar rings or seals are allowed to be used at the point where the cap seats on the insulator shell.
   In order to ensure effectiveness of the product during its useful life with respect to sealing between shell & cap and to reduce the corona on this area, the caps shall be flocked by providing coating protection made of “Polyamide Fibers”.

5 MECHANICAL AND DIMENSIONAL CHARACTERISTICS

5.1 Mechanical and Dimensional Characteristics with Ball and Socket Couplings

Type Designation as per IEC 60305	Electromechanical or Mechanical Failing Load (kN)	Maximum Disc Diameter D (mm)	Nominal Spacing P (mm)	Minimum Nominal Creepage Distance (mm)	Standard Coupling as per IEC 60120 (mm)
U 40 B	40	175	110	190	11
U 40 BP	40	210	110	295	11
U 70 BL	70	255	146	295	16
U 70 BLP	70	280	146	440	16
U 80 BL	80	255	146	295	16
U 80 BLP	80	280	146	440	16
U 100 BL	100	255	146	295	16
U 100 BLP	100	280	146	440	16
U 120 B	120	255	146	295	16
U 120 BP	120	280	146	440	16
U 160 BL	160	280	170	340	20
U 160 BLP	160	330	170	545	20
U 210 B	210	300	170	370	20
U 210 BP	210	330	170	545	20
U 240 B	240	300	170	370	24
U 240 BP	240	330	170	545	24

5.2 Mechanical and Dimensional Characteristics with Clevis and Tongue Couplings

Type Designation As per IEC 60305 / NTDC Standard	Electromechanical or Mechanical Failing Load (kN)	Maximum Disc Diameter D (mm)	Nominal Spacing P (mm)	Minimum Nominal Creepage Distance (mm)	Standard Coupling as per IEC 60471 (mm)
U 70 C	70	255	146	295	16 C
U 70 CP	70	280	146	440	16 C
U 80 C	80	255	146	295	16 C
U 80 CP	80	280	146	440	16 C
U 100 C	100	255	146	295	16 C
U 100 CP	100	280	146	440	16 C
U 120 C	120	255	146	295	16 C
U 120 CP	120	280	146	440	16 C
U 160 C	160	280	170	340	19 C
U 160 CP	160	330	170	545	19 C
*N 160 CP – 178	160	320	178	545	19 C

***** N refers to NTDC Special Class of insulators.

Note:

(i) The required insulator type and rating shall be as specified in contract/order.
(ii) Tolerances in Mechanical and Dimensional Characteristics are allowed as per IEC 60383-1, Clause 17 and IEC 60305, Clause 5.

Legends:

B: Specifies Ball & Socket

C: Specifies Clevis and Tongue

L: Designate long spacing

P: Designate long creepage distance insulators for polluted area

6 GALVANIZATION

All metal parts shall be hot dip galvanized in accordance with ASTM A153 "Specifications for Zinc coating (Hot-dip) on Iron and Steel hardware". The zinc coating should be continuous as uniform and as smooth as possible. However due to environmental conditions, to avoid the risk of premature aging the zinc coating thickness on the cap and pin shall not be less than 800 g/m². The purity of zinc used for galvanizing shall not be less than 99.99%.

7 TESTS

All tests shall be provided to NTDC for review and approval.

7.1 Type (Design) Tests

All type tests prescribed in the relevant IEC or equivalent ANSI standards shall be performed on the representative units or on the first unit of every new design or rating to be supplied to NTDC.

The temperature variation for thermal mechanical performance/load cycle test on string insulator unit shall be -35 ºC to +45 ºC.

In lieu of actual type (design) tests, certified test reports of Type (Design) tests on the identical units shall be submitted to NTDC for review and approval during Bid Stage as per NTDC Type Test Policy. Moreover NTDC may require the Contractor to perform all the type tests in accordance with the applicable standards to verify the main electrical and mechanical characteristics of an insulator unit, if the type test reports/results provided are not for the identical insulators to be supplied to NTDC.

Type (Design) Tests shall be valid for the period as specified in NTDC Type Test Policy, after which these tests shall be repeated in case of any further supply from the same manufacturer and from the same manufacturing plant. These tests may be repeated any time within the specified validity period if NTDC consider necessary for any particular project.

Type tests shall also be done if dimensions or materials described on manufacturers' drawings are modified or if manufacturing process or manufacturing place have been changed.

Following type tests are to be carried out in accordance with the requirements and methods laid down in the publications mentioned therewith:

i. Verification of Dimensions (as per approved drawings, Clause 5 of this specification and IEC 60383)
ii. Combined Mechanical and Electrical Strength Test (ANSI C29.2 B)
iii. Thermal Mechanical Performance Test (As per IEC 60383 and as indicated in sub – clause 8.1.6 of this specification)
iv. Autoclave Expansion Test for Portland Cement (As indicated in sub – clause 8.1.7 of this specification)

v. Radio Interference Test on High-Voltage Insulators (IEC 60437)
vi. Steep Wave Front Impulse Test (As per IEC 61211 and as indicated in sub – clause 8.1.8 of this specification)
vii. Dry Power Frequency Withstand Voltage Test (As per IEC 60383 and as indicated in sub – clause 8.1.15 of this specification)
viii. Wet Power Frequency Withstand Voltage Test (IEC 60383)
ix. Dry Lightning Impulse Withstand Voltage Test (As per IEC 60383 and as indicated in sub – clause 8.1.16 of this specification)
x. Power Arc Test (As per IEC 61467 and as specified in Clause 8.1.9 of this Specification)
xi. Residual Strength Test (ANSI C29.2 B)
xii. Impact Test (ANSI C29.2 B)
xiii. Cotter Key Test (ANSI C29.2 B)

7.2 Routine (Production) Tests

These tests are for the purpose of eliminating insulators with manufacturing defects. They are made on every insulator offered for acceptance by the manufacturer. Following routine tests are required in accordance with IEC & ANSI:

i. Visual Examination (IEC 60383)
ii. Mechanical Routine Tests (IEC 60383)
iii. Routine Thermal Shock Test (As indicated in sub – clause 8.1.13 of this specification)
iv. Heat Soak Test (As indicated in sub – clause 8.1.14 of this specification)

All routine (production) tests prescribed in the relevant IEC and/or ANSI standards shall be performed on all the insulator units prior to delivery to NTDC.

7.3 Sample (Quality Conformance) Tests

These tests are for the purpose of verifying the main characteristics of an insulator and the quality of the materials used. They are made on insulators taken at random from batches offered for acceptance.

All quality conformance tests required under this specification shall be made at the Manufacturer's factory and the Manufacturer shall furnish all tests apparatus and instruments along with its valid calibration certificates required for the tests. NTDC reserve the right to witness all the tests and to approve the schedule and procedures.

If required by NTDC, the Manufacturer shall make mechanical tests on the caps and pins as necessary to demonstrate their conformance to the specified requirements.

Two (2) copies of the results of routine factory test shall be submitted for each lot of 10000 units or fraction thereof whether or not inspection is conducted by the NTDC Representative.

7.3.1 Following sample tests shall be carried out in accordance with the standard mentioned therewith:

i. Verification of Dimensions (as per approved drawings, Clause 5 of this specification, ANSI C29.2 B and IEC 60383)
ii. Combined Mechanical and Electrical Strength Test (ANSI C29.2 B)
iii. Thermal Shock Test (ANSI C29.2 B) followed by Residual Strength Test (IEC 60797)
iv. Thermal – Mechanical Performance Test (As per IEC 60383 and as indicated in sub – clause 8.1.6 of this specification)
v. Autoclave Expansion Test for Portland Cement (As indicated in sub – clause 8.1.7 of this specification)
vi. Radio Interference Test on High-Voltage Insulators (IEC 60437)

vii. Steep Wave Front Impulse Test (As per IEC 61211 and as indicated in sub – clause 8.1.8 of this specification)
viii. Dry Power Frequency Withstand Voltage Test (As per IEC 60383 and as indicated in sub – clause 8.1.15 of this specification)
ix. Wet Power Frequency Withstand Voltage Test (IEC 60383)
x. Dry Lightning Impulse Withstand Voltage Test (As per IEC 60383 and as indicated in sub – clause 8.1.16 of this specification)
xi. Power Frequency Puncture Withstand Test (IEC 60383)
xii. Axial and Radial Displacement Test (IEC 60383)
xiii. Galvanizing Test (ATSM A153, A-239 and including purity of zinc test not less than 99.99%)
xiv. Zinc Sleeve Test (IEC 61325)

7.3.2 Locking Device for Ball & Socket Coupling

Following sample tests are to be carried out in accordance with the methods given in IEC 60372.

i. Visual Examination.
ii. Verification of Dimensions.
iii. Verification of Resistance to Bending.
iv. Hardness Test.
v. Operation Test.

All sample (quality conformance) tests prescribed in the relevant IEC and/or ANSI standards shall be performed on each lot of insulators prior to delivery to NTDC.

In addition to the above IEC or ANSI sample tests requirements, following sample tests shall be carried out:

a. A dimension test shall be performed on three (3) strings of six (6) insulators each selected at random and the connecting length of each string shall be six times the normal spacing of the insulators with the tolerance of ±19mm.

7.4 Special Tests

The artificial pollution test as a **Special Type Test** shall be performed in accordance with IEC 60507 and as mentioned in Clause 8.1.11 of this specification.

Note: The manufacturer must have its own testing laboratory to perform the above mentioned Routine and Sample tests as per this specification. Type tests shall be performed in NTDC designated STL Labs.

8 SAMPLING RULES, TEST METHODS AND ACCEPTANCE CRITERIA

8.1 Rules for Insulator sampling and their Distribution for Tests

8.1.1 For sample (Quality Conformance) tests, insulators shall be offered in lots of 10000 units or fraction thereof. The insulators intended for the sample tests shall be taken at random from each lot by the NTDC Representatives after performing routine tests of IEC publication 60383 or ANSI C29.2 B and elimination of defective insulator.

8.1.2 The number “n” of insulators to be selected is indicated in Table – I below:

TABLE – I: SAMPLING

Lot Size	Number of insulators selected from the Lot "n"	Number of insulators in the 1st partial sample "n1"	Number of insulators in the 2nd partial sample "n2"
"N" ≤ 300	Subject to Agreement		
300< N ≤ 2000	7	4	3
2000< N ≤ 5000	12	8	4
5000< N ≤ 10000	18	12	6

The total sample of "n" insulators is further divided into two partial samples composed of "n1" and "n2" insulators. When offered lot is more than 10000 insulators, they shall be divided into an optimum number of equal lots comprising between 2000 and 10000 insulators.

8.1.3 The sample of "n1" insulators is subjected to the following tests of IEC Publication 60383 or ANSI C29.2 B which are applicable in the order indicated. The acceptance criteria shall be in accordance with IEC 60383 or ANSI C29.2 B except for mechanical test and thermal mechanical test for which, the acceptance criteria mentioned in sub-clause 8.1.3.1 shall apply.

i. Verification of Dimensions.
ii. Axial and Radial Displacement Test.
iii. Galvanizing Test.
iv. Verification of Locking System.
v. Combined Mechanical and Electrical Strength Test.
The load shall be increased until the failing load of the insulator. The value obtained will be used for the statistical analysis. The acceptance criteria is specified in Clause 8.1.3.1.

8.1.3.1 While performing Combined Mechanical and Electrical Strength test and Thermal Mechanical Performance test the process for the criteria of acceptance shall be as follow:

1) Compute the quality index Qs with the following formula:

$$Qs = \frac{\overline{R} - Rs}{S}$$

In this formula:

- Average value $\overline{R} = \frac{R1 + R2 + \ldots\ldots\ldots\ldots\ldots + Rn1}{n1}$

R1, R2, R3,…… Rn1.are the measured values of electro – mechanical failing load.

- Rs: Specified value of the electro-mechanical failing load.

- S is the standard deviation:

$$S = \sqrt{\frac{\Sigma(R - \overline{R})^2}{n1 - 1}}$$

If Qs ≥ 3, the lot meets the acceptability criterion.

If Qs < 3, the lot does not meet the acceptability criterion.

8.1.4 The sample of "n2" insulators is subjected to the following tests of IEC Publication 60383 or ANSI C29.2 B which are applicable with the acceptance criteria specified in that Publication:

i. Verification of Dimensions.
ii. Axial and Radial Displacement Test.
iii. Galvanizing Test.
iv. Verification of Locking System.
v. Thermal Shock Test followed by Residual Strength Test.
vi. RIV Test.
vii. Dry Power Frequency Withstand Voltage Test.
viii. Wet Power Frequency Withstand Voltage Test.
ix. Dry Lightning Impulse Withstand Voltage Test.
x. Power Frequency Puncture Withstand Test.

8.1.5 Electro-Mechanical Failing Load Test

8.1.5.1 Test Method

The test shall be performed in accordance with ANSI C29.2 B. The applied load shall be increased up to the ultimate fracture of insulators and the fracture pattern shall be recorded.

8.1.5.2 Acceptance Criteria

i. Fracture pattern shall not change.
ii. The acceptance criteria shall be the same as indicated in sub – clause 8.1.3.1.
iii. The individual measured failing load shall not be lower than the rated value.
iv. Shattering should not occur before reaching the maximum load and the ultimate fracture.
v. Pattern and sequence of failure will be in adherence to the requirements specified by the manufacturer.

8.1.6 Thermal Mechanical Performance Test

8.1.6.1 Test Method

For thermal – mechanical performance test (10) insulator unit of each type shall be selected at random from the first lot (maximum lot size is defined as per sub – clause 8.1.1) and subsequently every seventh (7th) lot accumulatively brought for acceptance and tested in accordance with IEC Publication 60575; latest revision except that the temperature variation shall be from -35 ºC to +45 ºC and to a tensile load equal to 70% of rated Electrical and Mechanical Strength.

8.1.6.2 Acceptance Criteria

The criteria for acceptance of the lot shall be as below:

i. The results of the performance tests shall match the results of electro-mechanical or mechanical failing load test. Thus the specified electro-mechanical or mechanical failing load that applies to the ordinary electro-mechanical or mechanical falling load test should be reached also in the performance tests.
ii. The acceptance criteria shall be the same as indicated in sub – clause 8.1.3.1.
iii. Fracture pattern shall not change.
iv. Shattering should not occur before reaching the maximum load and the ultimate fracture.
v. The individual measured failing load shall not be lower than the rated value.

vi. Pattern and sequence of failure will be in adherence to the requirements specified by the manufacturer.
vii. The test equipment shall be such as to generate graph automatically as exhibited in Fig. 1 of IEC 60575. Graphs shall be Load – Time graph and Air Temperature – Time graph for a time period of 96 hours.

8.1.7 Autoclave Expansion Test for Portland Cement

Ten (10) cement / insulator unit samples shall be selected at random from every lot (maximum lot size is defined as per sub – clause 8.1.1).

The soundness of Portland cement to be used as the bonding agent for insulators shall be tested in accordance with ASTM C151 "Standard Test Method for Auto-clave Expansion of Portland Cement." Six (6) samples of cement for the test specimens shall be selected at random from the batch to be used for insulators.

The bars prepared from neat cement when subjected to high pressure steam at 2 ± 0.07 MPa [295 ± 10 psi] for three hours at 216 ºC shall not show an expansion of more than 0.12 percent. The expansion of cement more than 0.12 percent in the test shall cause rejection of the whole batch of cement brought for acceptance and insulators manufactured thereon from that cement batch.

Alternatively the soundness of Portland Cement may be tested on the full assembled insulators as described below:

Ten (10) insulator units of each type shall be selected as random and tested in accordance with the test apparatus and procedure laid down in ASTM C151. After this, each unit shall be subjected to combined mechanical and electrical strength test in accordance with ANSI C29.2 B or IEC 60383. The acceptance criteria shall be the same as for Combined Mechanical and Electrical Strength test as mentioned in Clause 8.1.3.1.

8.1.8 Steep Wave Front Impulse Test

Five (05) insulator units shall be selected for Type test. For Sample test Ten (10) insulator units shall be selected at random from the first lot (maximum lot size is defined as per sub – clause 8.1.1) and subsequently every seventh (7th) accumulatively brought for acceptance.

a. The impulse voltage puncture withstand test shall be carried out on the selected 10 insulators. Test voltage & test procedure shall be carried out in accordance with IEC 61211. Each insulator unit shall be subjected to a series of 5 positive, 5 negative, 5 positive, and 5 negative impulses in accordance with IEC 61211.

b. Puncture determination and acceptance criteria shall be as per the provisions laid down in IEC 61211.

c. The failure of any one unit either in steep wave front or subsequent low frequency flashover tests shall require testing of an additional twenty (20) units. Failure of any one unit from this group of twenty (20), to the tests mentioned in (a) and (b) above shall constitute failure to meet the requirements of these specifications and shall be cause for rejection of the lot brought for acceptance.

d. In case of non-acceptance of one lot, subsequent lots shall be tested till a successful test indicates the design of the insulators has been corrected.

8.1.9 Power Arc Test

The test shall be performed in accordance with IEC 61467 (short string method) with following considerations:

a. The short string shall comprise of six insulators.

b. The test series as prescribed in IEC shall be performed on 3 strings.

c. The test current characteristics shall be as specified in IEC (12kA and duration 0.1s).

d. The acceptance criteria shall be as specified in the IEC with following clarification:

For mechanical failing load test after the power arc application, the failing load on insulator shall be at least 70% of its breaking load with one minute hold period at 70% value.

8.1.10 Axial and Radial Displacement Test

8.1.10.1 Test Method

The test shall be performed in accordance with Clause 21 of IEC 60383-1.

8.1.10.2 Acceptance Criteria

Acceptance criteria for axial and radial displacement shall be as per IEC 60383-1.

8.1.11 Artificial Pollution Performance Test of Insulators

8.1.11.1 General Requirements

a. Artificial Pollution performance test shall be carried out in accordance with IEC 60507 and IEC 60060.

b. Test shall be performed using “Solid Layer Method” in conjunction with “Procedure B: Wetting after Energization” as given in IEC 60507.

c. Required level of NSDD shall be simulated using “Kaolin or Tonoko” composition as given in IEC 60507. ESDD shall be simulated by following salt composition:

$$NaCl : CaSO_4 : CaCO_3 = 50 : 25 : 25$$

Pollution/Contamination levels for this test shall be as follows:

ESDD (mg/cm^2)	NSDD (mg/cm^2)
0.25	2.50
0.50	2.50
0.75	2.50
1.00	8.00

d. Laboratory test shall be performed on short insulator string of five (05) insulators with “Up and Down method” of IEC 60060 to obtain critical flashover voltage i.e. $FOV_{50\%}$.

e. The performance of insulators shall be based on $FOV_{5\%}$ for 200 vertical strings (I-string/ V-string) in parallel.

f. Number of insulators per string for performance evaluation of insulators shall be specified by NTDC for each pollution level and corresponding transmission line voltage.

8.1.11.2 Test Procedure

Test voltage shall be applied to the short insulator string contaminated with specified pollution/contamination level and then the string shall be wetted with fog. Test voltage shall be maintained for hundred (100) minutes or until a flashover occurs. New short insulator string shall be used after each application. Effective number of test applications shall be at least equal to ten (10) using the “Up and Down” method with a suitable step voltage for achieving a satisfactory resolution of test results.

The test shall be repeated for all pollution/contamination levels as specified herein above. The $FOV_{5\%}$ (withstand voltage) for 200-Multiple string shall be derived from the

FOV $_{50\%}$ (critical flashover voltage) of the string or insulator unit in accordance with the procedure laid down in EPRI AC Transmission Line Reference Book - 200kV and Above.

Once the test is completed, $FOV_{50\%}$ and standard deviation shall be calculated using the test results for short string from ten (10) effective test applications as mentioned herein before. Finally, $FOV_{5\%}$ shall be calculated for the short string by using a normal probability distribution.

$$FOV_{50\%\,(single\ unit)} = \frac{FOV_{50\%\,(short\ string)}}{Number\ of\ Units\ in\ Short\ String}$$

$$FOV_{50\%(vertical\ string)} = n \times FOV_{50\%(single\ unit)}$$

$$FOV_{5\%(200\ vertical\ strings\ in\ parallel)} = 0.66 \times FOV_{50\%\,(vertcial\ string)}$$

8.1.11.3 Acceptance Criteria

Acceptance criteria for the artificial pollution performance test is that FOV5% for 200 strings in parallel (with the specified pollution level and corresponding number of insulators per string) shall be at least equal to specified phase to ground voltage.

8.1.12 Coordination with Hardware Fittings

In addition to above tests, the insulator manufacturer/supplier shall also coordinate with the hardware fittings manufacturer/supplier on the specific directions of the NTDC/Employer during the following tests on full scale suspension and tension assemblies to be carried out by the hardware fittings manufacturer/supplier:

i. Corona & RIV test.
ii. Power Arc Test.

8.1.13 Routine Thermal Shock Test

8.1.13.1 Test procedure

Before assembly with their metal components, the shells of toughened glass insulators shall be subjected to thermal shock tests as per following sequence:

a) Cold-to-hot: Each toughened glass shell shall be brought from ambient temperature to a temperature at least 300 °C higher and shall be maintained at this higher temperature for at least 1 min.
b) Hot-to-cold: Each toughened glass shell shall be quickly and completely immersed in water at a temperature not exceeding 50 °C, the shell having been heated by hot air or other suitable means to a uniform temperature at least 100 °C higher than that of the water.
c) Cold-to-hot: The cold-to-hot thermal shock specified in Item (a) shall be carried out a second time after completion of the procedure specified in Item (b).

8.1.13.2 Acceptance criteria

All toughened glass shells that shatter or fracture shall be rejected.

8.1.14 Heat Soak Test

8.1.14.1 Test procedure

To minimize the risk of spontaneous shattering by particles of Nickel Sulfide (NiS) in the glass, heat soak test shall be applied to ensure the complete elimination of NiS during the manufacturing process. The heat soak process cycle consists of a heating phase, a holding phase and a cooling phase.

Before assembly with their metal components, the shell of toughened glass insulators shall be subjected to soak-test in accordance with EN 14179-1.

8.1.14.2 Acceptance criteria

All toughened glass shells that shatter or fracture or any defect like frozen mark inside the glass shells observed shall be rejected.

8.1.15 Dry Power Frequency Withstand Voltage Test

This test shall be performed as per procedure of Wet Power Frequency Withstand Voltage Test described in IEC 60383 except the wetting process.

8.1.16 Dry Lightning Impulse Withstand Voltage Test

Dry Lightning Impulse Withstand Voltage test procedure and acceptance criteria shall be followed in accordance with IEC 60383. The normal procedure for determining the dry lightning impulse withstand voltage on single insulators and short standard strings shall be by calculation from the 50 % flashover voltage level determined by the up and down method described in IEC 60060-1.

9 MARKING

Each toughened glass insulator shall bear a durable marking in accordance with IEC 60383 Clause 5 or ANSI C29.2 B Clause 7 standards, identifying the following:

a. Manufacturer's Name or Trade Mark.
b. Year of Manufacture.
c. Combined Mechanical and Electrical Strength.
d. Country of Origin.

10 PACKING

The packing shall be as per general conditions of the contract/order. Moreover the following requirements shall also be applicable:

a. For all kind of insulators transportation, professional packing of short string shall be adequate for all transport type (marine, rail, road) and handling up to site in Pakistan.
b. The insulators should be carefully protected with adequate resistant film & packed in short string of 5 to 6 insulators maximum in solid wooden crates.
c. The wood craft should also have strong plastic strap with the view to guarantee stability and easy manual handling without any risk of external damage.
d. The crates should also stacked on treated wooden or reinforced plastic pallet bases and secured through additional suitable plastic traps in order to prevent any humidity or moisture and to avoid any insulators damage during shipment nor any dust ingress during transportation to the field storage or installation.
e. Each unit of insulator shall be crated, boxed or otherwise suitably protected against damage or loss during shipment and to facilitate field storage/handling.
f. Each insulator unit shall be properly packed to protect against the ingress of dust, dirt, moisture and other foreign matter.
g. The number of insulator units per crate shall be reasonable and the crates shall be designed for forklift handling. The crates shall be strong enough to support stacking of the crates to a maximum level of three crates high.
h. The manufacturer shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation as a result of improper packing.

i. For plant coated HVIC, a reinforced packaging of each unit is required in order to provide required additional protection of RTV Silicone coatings.

10.1 Crate or Pallet Marking

a. Insulator shell: Toughened Glass.
b. Insulator Type.
c. NTDC Contract Number.
d. Manufacturer's Catalogue Number.
e. Number of insulator in the crate and pallet.
f. Weight of one insulator unit.
g. Weight of one pallet.
h. Country of Production.

11 DRAWINGS AND DATA

11.1 Tender Drawings

The following information/documents shall be supplied with the bid. Failure to supply the same may cause disqualification of the bid:

i. Detailed fully dimensioned drawings of insulators.
ii. Specification giving material grade composition of all parts of the insulators, and locking arrangements.
iii. Catalogues/literature.
iv. Detail of manufacturing and testing facilities available with manufacturer.
v. The information indicated in tables provided above in the specification.
vi. Certified type test reports, shall be from an independent laboratory as listed in NTDC Type Test Policy.

11.2 Approval Drawings

All Information indicated in sub – clause 11.1 above shall be submitted for approval of the NTDC Design Engineer prior to commencement of mass production.

12 QUALITY ASSURANCE

The manufacturer shall ensure that a drivable and constant quality management system is in place for the selection & analysis of raw material, design and production of the insulators including statistical quality checks data to ensure compliance with the specification and all referred documents.

The quality management system shall include, but shall not be limited to the following:

a. ISO 9000 certification.
b. Current ISO 9001 Certification.
c. Current ISO 14001 Certification.
d. Current OSHAS 18001 Certification.
e. Quality plan identifying all the material, resources and process required for the manufacturer of the insulators, including all the hold points for inspection and testing.
f. Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw material are tested, list of tests normally carried out on raw materials in presence , copies of test certificates.
g. List of areas in manufacturing process, where stage inspections are normally carried out in quality.
h. Details of all the in process inspection and testing to be carried out.

i. Nonconformance procedures to ensure nonconforming insulators are not released/shipped to NTDC/end user.
a. Details of specific customer requirement where the design, packing, marking, shipping etc. differ from usual requirement.
b. Sample of Material Certificates.
c. Samples of Contractor's audit plan & reports.
d. Samples of sub – supplier qualification and evaluation report.
e. Samples of Certified Test reports.

13 SHATTERING PERFORMANCE CERTIFICATE

The manufacturer shall submit documentary evidence of satisfactory shattering performance of its supplied insulators by providing at least 3 certificates showing a self-shattering rate not more than 1/10,000 unit per year, from a minimum of 3 different Utilities/End-user at least one of which must be from Pakistan or outside the country of manufacturer.

NTDC has the right to verify the certificates of the manufacturer by contacting the Utilities/End-user which issued the submitted performance evidences.

14 RELIABILITY

14.1 The supplied material shall have minimum guaranteed service life of 30 years under the specified system and environmental conditions. Suppliers are required to comment on the reliability of the equipment and the performance of the materials offered and such comments shall include evidence in support of the reliability and performance claimed including information on Failure Mode and Effect Analysis.

14.2 The manufacturer of the insulators shall guarantee an insulator failure rate not exceeding one (1) per ten thousand (10,000) per year of toughened glass disc insulators. In case the annual failure rate during the first ten years of operation exceeds the above figure under normal operating conditions, as will be determined by check to be conducted as per mutually agreed procedure and conditions unto ten years (as permitted by the operating situation). The manufacturer shall supply to the purchaser free of cost spare insulators equal to 10 times the excess failure.

14.3 The manufacturer shall guarantee that there shall not be any de-capping and/or breakage of insulators on line due to any reason under normal operating conditions.

14.4 Before final acceptance, NTDC has the right to perform Technical audit of all undergoing Production Process starting from Raw material throughout different Quality Control step until finish Product and routine mechanical tests.

Encls: Flg-1 and Fig-2

Fig-1

String Insulator Units with Ball and Socket Couplings

As per IEC 60305

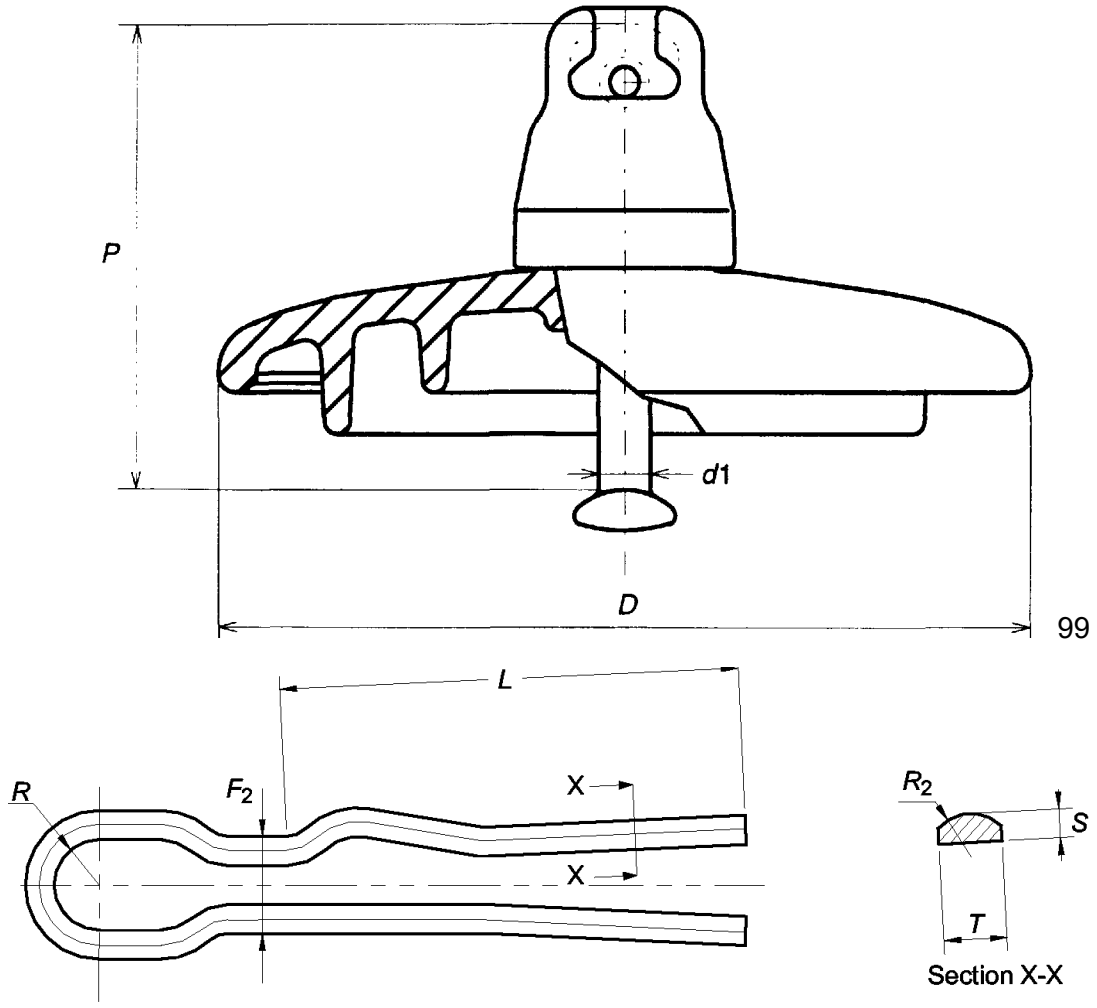
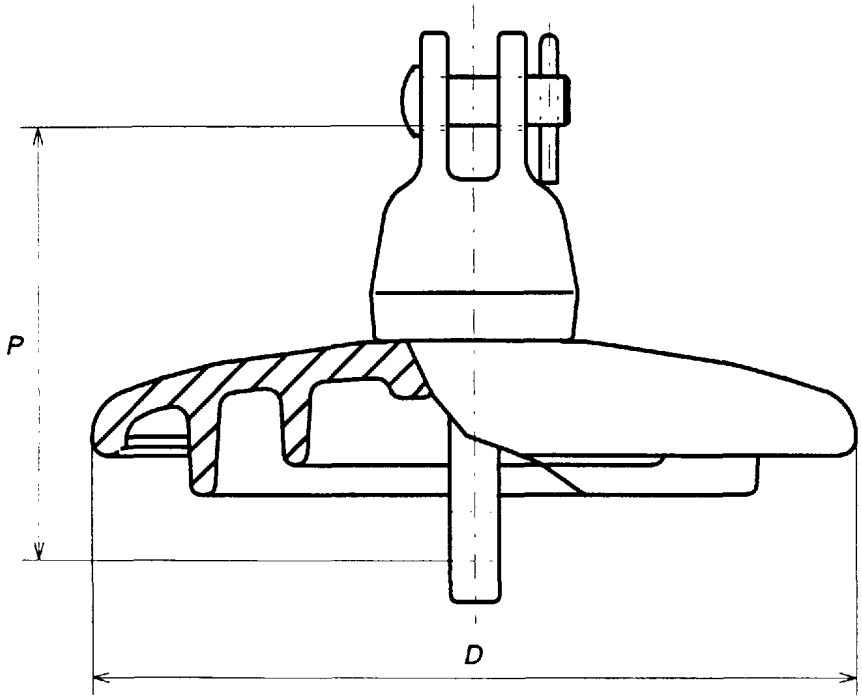


Fig-2

String Insulator Units with Clevis and Tongue Couplings

As per IEC 60305



SPECIFICATION TLMS-8A:2017

DESIGN (T/LINE) DEPARTMENT

NTDC

NON CERAMIC COMPOSITE INSULATORS FOR OVERHEAD TRANSMISSION LINES 132KV/220KV/500KV

PREPARED BY	REVIEWED BY	APPROVED BY
Manger Design, NTDC	G.M. (GSC) NTDC G.M. (GSO) NTDC G.M. (Services Division) NTDC G.M. (Technical) NTDC	Managing Director NTDC
Approved vide: Managing Director NTDC noting no.1594 dated 27.04.2017		

S.NO.	REVISION	DATE

TABLE OF CONTENTS

SPECIFICATION TLMS-8A:2016

Non Ceramic Composite Insulators,
For Overhead Transmission Lines 132KV/220KV/500KV

1.0 SCOPE

1.1 This specification specifies minimum technical requirements for design, engineering, manufacture, inspection, testing, performance and preparation for delivery of non-ceramic composite insulators for use in overhead transmission line system of National Transmission & Despatch Company (NTDC), Pakistan and DISCOs.

1.2 Non ceramic composite insulators shall be of following types:

Composite Long Rod Insulators for conductor tension and suspension application for system voltages rated 132kV, 220kV and 500kV.

2.0 DEFINITIONS

Core - The internal part of a composite insulator. The core is the mechanical load-bearing component of the insulator. The core consists mainly of glass fibers impregnated with a resin based matrix so as to achieve maximum strength. Also called a fiberglass-reinforced plastic (FRP) rod.

Type Tests - Tests to evaluate the electrical and mechanical design characteristics of the non-ceramic composite insulator which depend mainly on its shape and size. Also, these tests evaluate and verify the suitability of materials, interfaces, prototype design, and method of manufacture. These tests are performed only once and are considered valid for the whole class of insulators represented.

End Fittings, Metal - The metal attachment hardware that is connected to the insulator core that transmits the mechanical loads to the core at the ends of the insulator.

EPDM (Ethylene Propylene Diene Monomer) - Commonly used as a base polymer in non-ceramic composite insulator rubber formulations.

EPR (Ethylene Propylene Rubber) - The generic term that includes both EPDM and EPM.

Grading Device - A device for controlling the potential gradient at the end fittings.

Housing - The insulator component which is external to the core and contains both a sheath and weathersheds. The sheath–weathershed system protects the core and provides the required leakage distance.

Mechanical Load Test - A mechanical test for non-ceramic composite suspension insulators used to determine if a lot of insulators meet the Specified Mechanical Load (SML)

requirements. The historical failure loads from this test justify the manufacturer's choice of SML. Mechanical testing is also performed on every insulator to check its Routine Test Load (RTL) rating.

Non-Ceramic Composite Insulator - An insulator unit that is made from material other than porcelain, glass, or other ceramic material. It consists of a load-bearing resin-impregnated fiberglass core, metal end fittings, and external elastomeric housing.

Sample Tests/Factory Acceptance Tests (FATs) - Destructive or nondestructive tests that are used to verify insulator conformance to specific characteristics, quality of manufacture and determine acceptability of an insulator lot.

Routine Test - A test performed on every insulator from each lot to identify insulators with manufacturing defects by the manufacturer himself.

Routine Test Load (RTL) - The load applied to non-ceramic composite suspension insulators that is equal to or greater than 50 percent of the insulator Specified Mechanical Load (SML) rating. Also, considered to be the maximum continuous working load of the insulator.

Silicone Rubber (SR) - Usually in the form of polydimethylsiloxane, it is used as a base polymer in non-ceramic composite insulator rubber formulations. It is known for its hydrophobic (water-repellent) properties.

Specified Mechanical Load (SML) - A load specified by the manufacturer that represents the ultimate strength of a non-ceramic composite suspension insulator under tension. The strength should be verified during Mechanical Load Tests, and the historical failure loads should justify the manufacturer's choice of SML. It forms the reference point for selection of a non-ceramic composite suspension insulator. It is not the maximum working load of the insulator (see RTL). The SML of an insulator may be reduced by the class of hardware used for the end fittings.

Ultimate Strength - An insulator's tensile, compressive, or cantilever loading at which any part of the insulator fails to perform its function of providing mechanical support. Damage to the insulator core is likely to occur at loads lower than the insulator failing load.

Weathershed - The part of the insulator's housing which protrudes from the sheath and used to provide added leakage distance.

3.0 APPLICABLE CODES AND STANDARDS

The latest revision/amendments of the following Codes and Standards shall be applicable for the equipment/material covered in this Specification. In case of conflict, the bidder/manufacturer may propose equipment/material conforming to one group of Industry Codes and Standards quoted hereunder without jeopardizing the requirements of this specification.

ANSI C29.1 Standard Test Methods for Electrical Power Insulators

ANSI C29.2 Insulators, Wet-Process Porcelain and Toughened Glass, Suspension Type

ANSI C29.11 Composite Suspension Insulators for Overhead Transmission Line-Tests

ANSI C29.12 Insulators - Composite - Suspension Type

NEMA 107 Methods of Measurement of Radio Influence Voltage (RIV) of High Voltage Apparatus

IEEE Std. 4 High Voltage Testing Techniques

IEEE Std. 957 IEEE Guide for Cleaning Insulators

IEEE Std. 987 IEEE Guide for application of Composite Insulators

IEC 60383-1 Insulators for Overhead Lines with a Nominal Voltage above 1000V - Part 1: Ceramic or Glass Insulator Units for A.C. Systems - Definitions, Test Methods and Acceptance Criteria

IEC 60383-2 Insulators for Overhead Lines with a Nominal Voltage above 1000V - Part 2: Insulator Strings and Insulator Sets for A.C. Systems - Definitions, Test Methods and Acceptance Criteria

IEC 60507 Artificial Pollution Tests on High Voltage Insulators to be used on A.C. Systems

IEC 60587 Test methods for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions

IEC 61109 Composite Insulators for A.C. Overhead Lines with a Nominal Voltage greater than 1000V - Definitions, Test Methods and Acceptance Criteria

IEC 61466-1 Composite String Insulator Units for Overhead Lines with a Nominal Voltage greater than 1000V - Part 1: Standard Strength Classes and End Fittings

IEC 61466-2 Composite String Insulator Units for Overhead Lines with a Nominal Voltage greater than 1000V - Part 2: Dimensional and Electrical Characteristics

IEC 62217 Polymeric insulators for indoor and outdoor use with a nominal voltage greater than 1 000 V – General definitions, test methods and acceptance criteria

IEC 61467 Insulators for overhead lines with a nominal voltage above 1000V AC power arc tests on insulator sets

IEC TS 62073 Guidance on the measurement of wettability of insulator surfaces

IEC 60437 Radio Interference Test on High-Voltage Insulators

IEC 60815 Selection and Dimensioning of High-Voltage Insulators intended for use in Polluted Conditions

IEC 60060 High Voltage Test Techniques

IEC 60120 Dimensions of Ball and Socket Couplings of String Insulator Units

IEC 60471 Dimensions of Clevis and Tongue Couplings of String Insulator Units

ASTM A153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM B499 Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method; Nonmagnetic Coatings on Magnetic Basis Metal

ASTM D2240 Test Method for Rubber Property—Durometer Hardness

This specification shall also be read in conjunction with Purchase Order or Contract Schedules for project, as applicable.

The manufacturer will provide purchaser with latest editions of the above listed applicable standards. It is the responsibility of the manufacturer to provide copies of latest editions of above mentioned standards to the Inspector at least two (02) weeks prior to start of testing.

4.0 DESIGN REQUIREMENTS

The design, fabrication, material, processes, tolerances and inspection of composite insulators shall conform to the following:

4.1 General

4.1.1 Language and Units: All correspondence, literature, drawings and markings shall be in English language. All dimensions shall be in SI units (Metric System).

4.1.2 The composite insulators shall be of manufacturer's standard design but shall meet or exceed the requirements of this specification in all respects.

4.1.3 The manufacturer's design drawings shall show the outline of the composite insulators, together with all pertinent dimensions and ratings. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

4.1.4 The drawings shall include principal dimensions (i.e. length, core diameter, leakage distance, dry arc distance, number of sheds, diameter of weathersheds and weathersheds spacing, details of end fittings and corona rings) and shall be representative of the actual shed profile.

4.1.5 The drawings shall also include the basic mechanical and electrical characteristics of insulator, approximate weight of one insulator unit, type of the material used for the sheath and weathersheds and the material of the corona rings and end fittings.

4.2 Design Criteria

4.2.1 The composite insulator weathershed design shall be aerodynamic type with good self-cleaning properties without any under ribs. Insulator shed profile, spacing, projection and selection in respect of polluted conditions shall be in accordance with recommendation of IEC 60815.

4.2.2 The composite insulator couplings i.e. ball & socket / tongue & clevis, must be IEC compatible.

4.2.3 The maximum diameter of the composite insulator weathershed shall be 200mm.

4.2.4 Services conditions as specified in the Purchase Order or Contract Schedules shall serve as the basis of design criteria and shall be provided by the purchaser as attached in Annexure-I.

4.3 Ratings

4.3.1 The composite insulators shall have the Voltage Class, SML strength ratings and coupling types as listed in Table-I below:

Table-I

Nominal System Voltage (kV)	Coupling (IEC 60120/60471)	Specified Mechanical Load (SML)		Min. Leakage Distance (mm)	Maximum Permissible Section Length (mm)
		Suspension Application (kN)	Tension Application (kN)		
132	Ball & Socket	80	-	3888	1314
		80	-	4752	1606
		80		5616	1898
		-	100	3888	1314
		-	100	4752	1606
			100	5616	1898

220	Ball & Socket	100 -	100 160	6480 6540	2190 2136
500	Tongue & Clevis	80 80 80 80 160 160 160 160	- - - - 160 160 160 160	12528 15984 19872 23328 12535 16350 19620 23435	4234 5402 6716 7884 4094 5340 6408 7654

Notes:

i. Maximum permissible section lengths are given in the above table. Nominal section lengths corresponding to above leakage distance requirements/insulation levels shall be provided by the manufacturer.
ii. The tolerances specified in IEC 61109 are applicable to the nominal length.
iii. The required mechanical and electrical strength and type of string; I-suspension (single/double suspension), V-suspension and tension string (single/double/triple/quad tension) shall be specified in the data schedule.
iv. For replacement of existing porcelain disc insulator strings with non-ceramic composite insulators, the bidder/manufacturer shall ensure the compatibility of end fittings with the line hardware whilst satisfying all the requirements of this specification.

4.3.2 The electrical withstand values of composite insulators shall be in accordance with Annex-I. The electrical withstand values shall be met with corona rings installed on the line end of the insulators.

4.3.3 The maximum radio-influence voltage (RIV) shall be 100 microvolts at 1000 kHz.

4.3.4 The composite insulator's Mechanical and Electrical characteristics shall be as specified in Data Schedule given in this specification.

4.3.5 The composite insulators shall have hydrophobicity of silicone rubber material classified Wettability Class 1 (WC-1) or better per IEC 62073. Accordingly, receding water contact angle shall be 80° or more.

4.4 Material and Workmanship

4.4.1 The complete composite insulator shall consist of a Fiberglass Reinforced Plastic (FRP) core having superior electrical and mechanical performance, sheath (housing), weathersheds and metal end fittings.

4.4.2 The composite insulator surface shall be shaped and spaced for effective natural cleaning and effective use of leakage distance for coastal/desert/humid/industrially polluted and other environments as mentioned in service conditions by the purchaser.

4.4.3 The composite insulators shall be fabricated through one of the following processes:

a. High Temperature Vulcanized (HTV) Silicone Rubber Insulators, Single-Piece Molded Design

The housing (sheath and weathersheds) shall be directly applied on to the FRP core in one single-step (compression molding) through high temperature vulcanization process. Any seams/burrs protruding axially along the insulator resulting from this process, shall be removed completely. Injection molding is acceptable only in case the housing is molded in one single-shot. Molding in multiple steps may cause flaws and the residual stress in the joining seams and, therefore, shall not be acceptable.

b. High Temperature Vulcanized (HTV) Silicone Rubber Insulator, Modular Design

A sheath shall be extruded seamlessly on to the FRP core. The housing shall be completed by assembly of molded weathersheds on to the sheath. All parts of the insulating body, i.e., FRP core, sheath and the weathersheds shall be bonded together by high temperature vulcanization.

c. Liquid Silicone Rubber (LSR) Insulators

Full size, one -piece insulator housing (sheath and weathersheds) shall be produced in one molding step by applying low viscosity liquid silicone rubber with low silica filler content.

4.4.4 The insulators shall be of appropriate length to provide the required leakage distance and the electrical performance in one single unit. In-line coupling of two or more units shall not be acceptable. No radial joints shall be made along the length of the sheath regardless of the distance between the end fittings. The sheath shall be extended inside the end fittings to protect and hermetically seal the fiberglass core from moisture. The interface between the FRP core and the end fitting shall be sealed to effectively eliminate the possibility of moisture ingress for the life of the insulator.

4.4.5 The composite insulators shall be capable of withstanding high pressure power washing. To prove this property, a power wash test shall be performed per Clause 5.5.3. The manufacturer will define washing intervals for insulators considering site contamination severity and required pollution performance along with specific washing consideration required to be followed to protect insulators from mechanical damage.

4.4.6 The composite insulators shall be capable of withstanding the power arc test, followed by radio influence and corona tests and finally verification of residual mechanical strength.

The insulators shall be compatible for use with hot line or live line maintenance techniques so that usual hot line operations can be carried out with ease, speed and safety and the manufacturer will furnish the method of hot and cold line maintenance.

4.4.7 Core

4.4.7.1 The internal core shall be a glass-fiber reinforced FRP rod consisting of E-glass fibers and epoxy based resin.

4.4.7.2 To reduce risk of brittle fracture the insulator FRP core shall be made of electrical corrosion resistant (ECR) boron free glass rod and shall achieve the specified electrical and mechanical characteristics. The FRP core shall be resistant against hydrolysis under service conditions.

4.4.7.3 During fabrication of the glass core, the glass strands in the insulator core shall not be allowed to touch one another without resin matrix surrounding each individual fiber. Fibers shall be continuous between rod ends and oriented parallel to the rod axis. Glass content shall equal or exceed 60 percent by volume of the fiberglass-epoxy mixture. All areas in the rod not occupied by fiberglass strands shall be filled with epoxy. All fiberglass strands and epoxy shall be fully bonded together.

4.4.7.4 The composite insulator core shall be mechanically and electrically sound, free from voids, foreign substances, and manufacturing flaws. The design shall be such as to ensure that the core is totally encapsulated and fully sealed, from the live end to earthed ends, by the insulating material from the environment, in order to avoid ingress of moisture. If any tacky substances are used as sealers, they shall not be exposed to environmental influence.

4.4.7.5 The core shall have the same diameter throughout the entire length of the rod. Long composite insulators bend easily due to their own flexibility by a small load during transportation, handling, installation, etc., and an excessive bending has a danger of damaging the core. To avoid any risk of damage, FRP core shall have a minimum of Φ24mm diameter for 500kV applications which shall prevent such excessive bending. To verify the suitability of the FRP core diameter a bending test shall be performed in accordance with acceptable industry practice. The manufacturer shall submit the necessary details for review and acceptance by purchaser.

4.4.7.6 The insulator unit shall possess the required compression strength for application in vee-string configuration and torsional strength for application in horizontal tension string configuration to prevent damage during the construction and operation phases. The manufacturer shall provide the maximum permissible limits of these strengths.

4.4.8 Housing

4.4.8.1 The core of composite insulator shall be completely covered by a continuous housing consisting of a sheath-weathershed system.

4.4.8.2 The composite insulator sheath and weathersheds insulating material shall have a chemical structure of 100 percent silicone rubber before fillers are added. The finished product shall be ultraviolet (UV) radiation exposure resistant. The finished product shall be unaffected by atmospheric conditions due to weather, proximity to the coast, fumes, ozone, acids (particularly sulphuric acid present in the prevailing environment of oil field areas in the region), alkalies, dust or rapid changes to air temperature. There shall be no material degradation such as development of surface cracks and increase in surface hardness, etc.

4.4.8.3 The weathersheds and sheath shall be bonded together during the vulcanization process or molded into one piece by injection/compression molding. The sheath shall be bonded to the rod or have a void-free silicone interface. The housing shall be bonded to the metal end fittings or be properly sealed to prevent moisture or contaminant ingress to the FRP rod. The housing shall fully protect the fiberglass rod for the service life of the insulator. The housing shall be smooth and free from imperfections. There shall be no holes or gaps in the housing at any point along the length of the insulators.

4.4.8.4 The strength of the silicone rubber to FRP core and weathershed to sheath interface shall be greater than the tearing strength of the silicone rubber.

4.4.8.5 The composite insulators thickness of the sheath or weathershed covering over the core shall be greater than 3.0 mm. The sheath-weathershed should have silicone content minimum 30% by weight.

4.4.8.6 The track resistance of the sheath and weathersheds material shall meet the requirements of IEC 60587 method 1 class 1A4.5.

4.4.8.7 The sheath and weathersheds material of insulators fabricated from high temperature vulcanized silicone rubber shall have a Shore 'A' hardness of not less than 60.

4.4.8.8 The composite suspension and tension insulators shall be of alternating shed design with aerodynamic type profile and without any under-ribs designed in accordance with IEC 60815-3. Weathersheds shall be at intervals to provide optimum electrical performance and the weathershed design shall provide a protected bottom surface that tends to keep dry in wet conditions.

4.4.8.9 The manufacturer shall determine if additional leakage distance is required based on the long term performance of the housing material and the proposed insulator environmental conditions.

4.4.8.10 The manufacturer shall provide the owner documentation which demonstrates satisfactory test results of specific formulations subjected to applicable environmental contamination together with satisfactory performance data of insulators (manufactured of the specified formulation) which have been installed on existing utility lines energized at the same voltage and in the same type of proposed environment.

4.4.8.11 The core/housing interface shall be manufactured so as to prevent leakage current flow over the surface of the core. The color and consistency of the material shall be uniform.

4.4.9 Metal Parts

4.4.9.1 The composite suspension insulator end fittings shall be designed to transmit the mechanical load to the FRP core and to develop the uniform and the consistent mechanical strength of the insulators.

4.4.9.2 Metal parts shall be made of the best commercial grade of malleable iron, ductile iron or steel, and shall be hot-dip galvanized in accordance with ASTM A153. Metal parts shall be weatherproof and corrosion and /or abrasion resistant.

4.4.9.3 The contours of the metal parts for composite insulators shall be uniform and without sharp edges or corners and shall be free of cracks, flakes, slivers, slag, blow-holes, shrinkage defects, and localized porosity and shall be designed such as to eliminate areas of high electrical stress concentrations.

4.4.9.4 The composite insulator's end fittings shall be attached to the FRP core through compression crimping process so that the end fittings uniformly transmit the mechanical load to the FRP core while providing a strength equal to or greater than the defined and specified ultimate strength of the insulator. The crimping process shall be performed with a symmetrically controlled crimping method that compresses the metal radially onto the rod and controlled by a specific method such as Acoustic Emission Detector to ensure that there is no damage to the core during the compression crimping operation.

4.4.9.5 Each insulator shall be permanently sealed at the interface between the metal end fittings and the housing to ensure that no moisture or foreign materials shall enter.

4.4.9.6 The metal end fittings and the housing of composite insulators after complete assembly shall be coaxial with one another and with the core, resulting in no eccentric loading.

4.4.9.7 The composite insulator end fittings at the line end shall be terminated with an IEC Class ball or clevis and at the grounded end with an IEC class socket or tongue couplings.

4.4.9.8 Cotter keys shall be grade 304L stainless steel (minimum grade).

4.4.9.9 Bolts, nuts, and spring lockwashers shall be made of steel and hot-dipped galvanized in accordance with ASTM A153, unless otherwise specified. Bolts may have either rolled or cut threads and shall have thread engagements capable of developing the specified strength of the unit. Nuts may be re-threaded after galvanizing to ensure clean threads, but bolts shall not be threaded or re-threaded after galvanizing. Threaded holes and nut threads shall be tapped oversize to closely fit those of the galvanized bolt with no unnecessary looseness, but free enough to permit the nut to be turned on freely with the fingers over the entire thread length.

4.4.10 Grading Devices

4.4.10.1 For composite insulator applications at 132kV and above, a grading ring shall be provided at the line end of the insulator. This shall control electrical stresses and ensure noise free insulator applications. The diameter of the ring and the tube shall be large enough to avoid local corona inception. For application at 500kV, a grading ring shall be provided at each end of the insulator.

4.4.10.2 The manufacturer shall provide purchaser with documentation that the insulator design with applicable grading devices will minimize or eliminate corona discharge activity under wet and dry conditions for the type of tower/pole-top configuration proposed. The effects of corona discharge activity on insulator life shall be negligible.

4.4.10.3 Due consideration shall be given to electric field concentrations at the live end to avoid excessive local electric stress. The design shall be demonstrated by 3-D electric field modeling of complete insulator unit along with associated corona and power arcing devices and tower/pole top proximity effects, results of which shall be provided to purchaser. Manufacturer should provide reports of successful electric field modelling testing for the specific insulator design. The EMF should be three dimensional with results containing drawing depicting the electric field in various colors, each of a different voltage level. The result of this study should show that the voltage field surrounding the composite insulator is optimum along the entire length of insulator, with the effected hot end of the insulator being a critical location. The threshold at which corona may or may not be present should be defined as a figure in kV/mm for the designated insulator.

4.4.10.4 To prevent or reduce the discharge activity due to corona/dry-band arcing, the surface electric field magnitudes on the weathershed material and surrounding end fitting seal shall not exceed 4.5kV/cm (rms) measured 0.5mm above the surface of sheath under dry and uncontaminated conditions.

4.4.10.5 All grading rings and brackets shall be designed as an integral part of the insulator assembly with a positive mounting system that allows mounting in only one position. The design of the grading ring shall be such that the ring can only be mounted with its orientation towards the weathersheds for maximum RIV and corona control.

4.4.10.6 Grading rings shall be designed in such a manner that the rings can be readily installed and removed with hot line tools without disassembling any other part of the insulator assembly.

4.4.11 Workmanship

4.4.11.1 Materials specified in the design and fabrication requirements of this specification shall be unused, recently manufactured, and free of defects or irregularities. The manufacturer is required to provide certificates of source material to the purchaser in this regard.

4.4.11.2 All components of the same design and designation shall be identical, and like components shall be interchangeable.

4.4.11.3 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.

4.4.12 Markings

4.4.12.1 All the individual insulators and crates shall be provided with legible and durable markings as detailed below:

4.4.12.2 Insulator Markings

Each composite insulator shall bear a permanent marking in accordance with ANSI or IEC Standard on the end fitting. All the characters shall be legible, durable and permanently marked on one end fitting or on the uppermost shed of the insulator as follows. The use of labels shall not be permitted:

a. Manufacturer's Name or trademark
b. Year of Manufacture and serial number with Lot Number (if the order is large enough to contain lots).
c. Nominal System Voltage
d. Creepage/Leakage Distance or Section Length
e. Specified Mechanical Load (S.M.L.) in kN
f. Routine Test Load (R.T.L.) in kN
g. Country of Origin

4.4.12.3 Crate Markings

Each crate shall be marked with the following identifications:

a. Insulator Type and number of insulators
b. Manufacturer’s Name
c. Purchase Order Number/Contract Number
d. TLMS-8A:2016
e. Manufacturer’s Catalog No
f. Production Lot Number

5.0 QUALITY ASSURANCE MECHANISM

5.1 The manufacturer should be ISO 9001 certified and shall furnish a description of its Quality Assurance Program including fabrication, testing, and inspection. Any material (i.e., EPR), components (i.e., rod) or hardware (i.e., end fittings) the manufacturer has had fabricated by others should also be included.

5.2 The manufacturer shall furnish necessary documentation with regards to the manufacturing method and material compositions for record and future reference of purchaser.

5.3 The manufacturer shall maintain a development and engineering department to provide a technical after sales service and information related to the insulators.

6.0 INSPECTION AND TESTING

All test results shall be provided for review and acceptance by purchaser. The electrical tests shall be performed on composite insulators with grading ring(s), if applicable. *The type testing, in case of award, will be arranged at one of the STL accredited laboratories.*

6.1 Type Tests

6.1.1 All type tests prescribed herein below shall be performed on the representative composite insulator unit or on the first unit of every new design or rating to be supplied to purchaser.

6.1.2 The following type tests are to be carried out in accordance with the requirement and methods laid down in the standards/clauses mentioned therewith.

On Complete Composite Insulator along with Hardware Fittings

1.	Wet power frequency test	IEC 61109
2.	Dry lightning impulse withstand voltage test	IEC 61109
3.	Wet switching impulse withstand voltage test (for 500kV)	IEC-61109
4.	Pollution test	As per Clause 6.1.4
5.	Power arc test	IEC 61467
6.	Corona and RIV test	As per Clause 6.1.5
7.	Electric field modelling test (Applicable to 220kV and 500kV voltage)	As per requirements laid down in Clause 4.4.10

Note:
The insulator manufacturer shall have to coordinate testing of insulators with hardware fittings to be supplied by other manufacturer and shall have to also guarantee overall satisfactory performance of the insulators with the hardware fittings.

On Composite Insulator Units

1.	Tests on interfaces and connections of end fittings a) Sudden load release pre-stressing b) Thermal-mechanical pre-stressing c) Water immersion pre-stressing	IEC-61109

	d) Verification tests e) Visual examination f) Steep-front impulse voltage test g) Dry power-frequency voltage test	
2.	Tests on shed and housing material a) Hardness test b) Accelerated weathering test c) Tracking and erosion test d) Flammability test	IEC-61109
3.	Tests on core material a) Dye penetration test b) Water diffusion test	IEC-61109
4.	Assembled core-load time test a) Determination of the average failing load of the core of the assembled insulator b) Control of the slope of the strength-time curve of the insulator	IEC-61109
5.	Damage limit proof test and test of the tightness of the interface between end fittings and insulator housing	IEC-61109
6.	5000 hours ageing test	As per Clause 6.1.3
7.	Artificial pollution test	As per Clause 6.1.4
8.	High pressure water withstand test	As per Clause 6.1.6
9.	Brittle fracture resistance test	As per Clause 6.1.7
10.	Torsional load test	As per Clause 6.1.8
11.	Grading device test	As per Clause 6.1.9
12.	Recovery of hydrophobicity test	As per Clause 6.1.10

6.1.3 5000 hours Ageing Test

The test on housing shall include a minimum 5000 hours ageing test under operating voltage in accordance with Annexure C of IEC 61109-1992.

6.1.4 Artificial Pollution Test

The pollution test shall be performed in accordance with IEC 60507.
The type, procedure and contamination levels of Artificial Pollution Test shall be specified in the Purchase Order or Contract Schedules. Purchaser will require the bidder/manufacturer to perform one of the following Artificial Pollution Test (Salt Fog or Solid Layer Method):

a. Specified Withstand Voltage
b. 50 % Withstand Voltage

When, the Solid Layer Method is opted, the test shall be performed in accordance Procedure B – Wetting after energization.

To account for decrease in flashover voltage with increased NSDD (Non-Soluble Salt Deposit Density), NTDC will specify the project site NSDD (instead of the IEC recommend level of 0.1mg/cm^2) based on previously conducted contamination surveys.

6.1.5 RIV/Corona Test

To verify the requirements of Clause 4.3.3, radio influence voltage and visible corona tests shall be performed in accordance with ANSI C29.12.

6.1.6 The High Pressure Water Withstand Test

a. A power water wash test shall be performed on the composite horizontal line-post or composite suspension insulator in accordance with IEEE Std. 957 to demonstrate that the insulators can be power washed. The test shall be a water spray at a shed seam approximately 3 meters from the insulators. The spray shall be a solid stream through a 6mm diameter nozzle at 3800 kPa for a period of 10 (ten) minutes. There shall be no signs of water penetration through the housing or under the outside weathersheds into the core or at the silicone rubber sheath-hardware interface into the core.

b. The soundness of the insulators after washing shall be demonstrated by performing electrical tests (lightning impulse withstand/flashover and power frequency dry/wet withstand/flashover tests) followed by a mechanical test in accordance with the relevant IEC standard.

6.1.7 Brittle Fracture Resistance Test

The resistance of FRP core against brittle fracture shall be proven by a test on resistance of the FRP core against stress corrosion. The test shall be performed at an ambient temperature to confirm the mechanical resistance of the FRP core against stress corrosion. The test shall be performed as below:

a. One insulator sample from the first production lot or one specimen shall be used. The specimen shall have a length between end fittings of at least 10 times the core diameter. The end fittings shall be identical to those used in the production. The housing of the insulator shall be removed in the middle part of the insulator on a length of at least 150mm. The visible FRP core surface shall be smoothened by means of a fine abrasive cloth and the remaining parts of the housing shall be removed thoroughly.

b. An acid container made of polyethylene shall be arranged, surrounding the visible core surface in such a way that the liquid can simply be poured into the container and no acid comes into contact with the fittings. The size of the acid chamber shall be adapted in such a way that the FRP core is surrounded by a liquid thickness of not less than 10mm

and a liquid level of not less than 40mm. The container shall be covered to limit evaporation of the liquid to maximum 5% of its volume during the test period.

c. The insulator shall be subjected to a tensile load applied between the metal fittings. The tensile load shall be increased rapidly but smoothly, from 0 to 67% of the specified mechanical load (S.M.L.) and then be maintained at this value for 96 hours. Immediately after applying a load, a nitric acid of a concentration 1 normal (63 gram of HNO3 added to 937 gram of water) shall be poured into the acid container. The acid must not come into contact with the end fittings.

d. The insulator shall be considered to pass the test if no fracture of the FRP core occurs during the 96 hours period.

6.1.8 Torsional Load Test

A torsional load of 55Nm shall be applied to the test specimens through a torque member so constructed that the specimens are not subjected to any cantilever stress. Insulators after torsion must pass the Dye Penetration Test as specified in IEC 61109.

6.1.9 Grading Device Test

Grading devices shall be tested using a mechanical shaker with at least a one inch (2.54cm) stroke at the grading device and a frequency of no less than three cycles per second for a duration of 2,000,000 cycles. Movement shall be along the long axis of the insulator. The test shall reflect the manufacturer's recommended method for attaching the grading device to the insulator. The grading device shall be attached to the insulator and the insulator attached to the shaker in a vertical position. The test shall be considered successful if no movement is detected in the ring with respect to the insulator and there is no physical damage to the grading device and the attachment assembly.

6.1.10 Recovery of Hydrophobicity Test

a. 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.
b. Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester. Holding the electrode approximately 3 mm 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.
c. 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 to 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.
d. 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.

6.2 Routine Tests

The following routine tests prescribed herein below in accordance with the requirement and methods laid down in the standards mentioned therewith shall be performed by the manufacturer on all units prior to sample testing/FATs, to eliminate insulators with manufacturing defects. The manufacturer shall provide the purchaser with certified test reports for routine tests.

1. Mechanical Routine Test — IEC-61109
2. Visual Examination — IEC-61109

6.3 Sample Tests/FATs

All sample tests prescribed herein below in accordance with the requirement and methods laid down in the standards mentioned therewith shall be performed on each lot of insulator at random prior to delivery to purchaser.

1. Verification of dimensions — IEC-61109
2. Verification of locking system — IEC-61109
3. Verification of tightness of the interface between end fittings and insulator housing — IEC-61109
4. Verification of specified mechanical load (SML) — IEC-61109
5. Galvanizing test — IEC-61109

Sampling, Acceptance and Rejection

The sampling shall be done as follows:

a) Verification of dimensions ..... (E1 + E2)
b) Verification of the locking system ..... .(E2)
c) Verification of the tightness of the interface between
end fittings and insulator housing ..... (E2)
d) Verification of the specified mechanical load, SML .....(E1)
e) Galvanizing test .....(E2)

Lot Size N	Sample Size	
	E1	E2
N≤300	Subject to agreement b/w purchaser and supplier	
300<N≤2000	4	3
2000<N≤5000	8	4

5000<N≤10000	12	6

In the event of a failure of the sample to satisfy a test, the re-testing procedure shall be applied as prescribed below.

Insulators of sample E2 only can be used in service and only if the galvanizing test is performed with the magnetic method.

Re-testing procedure

If only one insulator or end fitting fails to comply with the sampling tests, re-testing shall be performed using a new sample size equal to twice the quantity originally submitted to the tests.

The re-testing shall comprise the test in which failure occurred.

If two or more insulators or metal parts fail to comply with any of the sampling tests, or if any failure occurs during the re-testing, the complete lot is considered as not complying with this specification and shall be withdrawn by the manufacturer.

Provided the cause of the failure can be clearly identified, the manufacturer may sort the lot to eliminate all the insulators with this defect. The sorted lot may then be re-submitted for testing. The number then selected shall be three times the first quantity chosen for tests. If any insulator fails during this re-testing, the complete lot is considered as not complying with this specification and shall be withdrawn by the manufacturer.

6.4 Test Reports

Test reports shall include information that allows purchaser to clearly identify the units tested. The following information shall be included on the test reports:

- Purchase Order Number
- Shipment Date
- Destination
- Catalog Numbers
- Specified Mechanical Load of the Insulator's Core
- IEC Class End Fittings
- Number of Lots in the Shipment
- Number of Insulators in Each Lot
- Lot Code Numbers
- Date of Testing
- Name of Individual(s) Documenting the Tests

7.0 PACKAGING AND SHIPPING

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

7.1 Insulator Packaging

7.1.1 All insulators shall be packed in suitable PVC/plastic tubes/any other suitable packing along with temporary wrap-on shields/shrouds for each insulator unit. The packing shall provide protection against rodent etc. The shields/shrouds shall be for protection during transport and for preventing bird pecking during erection. Further, the shields/shrouds shall be made of opaque, weather proof material of adequate strength and shall be color coded. The shields/shrouds shall have smaller diameter than the insulator to stay in place against winds & weather and shall be designed so as to leave only the end fittings exposed for attachment of insulator to tower and line hardware until line construction is complete. The shield/shroud shall have suitable pull off loop for easy detachment just prior to charging of the line without causing any damage to the insulator. The manufacturer shall furnish detailed design of the packing and shield/shroud along with attachment and detachment procedure in this regard. For marine transportation, crates shall be palleted.

7.1.2 For marine transportation, Insulators shall be packaged in wooden crates completely enclosed on all sides with plywood and internal wooden supports constructed so each layer of insulators is self-supported by their own end fittings and not supported by a lower layer of insulators.

7.1.3 Wooden crate shall be treated to resist degradation using treating materials that have been determined not to harm the environment or the enclosed insulator in any manner.

7.1.4 Packaging in crates shall be such that Weathersheds shall not rest against adjacent insulator weathersheds such that bending of the weathershed occurs.

7.1.5 The number of insulator units per crate shall be reasonable and the crates shall be designed for forklift handling. The crates shall be strong enough to support stacking of the crates to a maximum level of three crates high.

7.1.6 All crates shall be marked legibly and correctly as per Clause 4.4.12.3.

7.1.7 The manufacturer 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.

7.2 Grading Device Packaging

7.2.1 The appropriate number of grading devices shall be packaged in a separate enclosed container and shipped in the same wooden container as the insulators they attach to. If the grading devices are large, or the grading device container may damage the insulators during shipment, the grading devices may be shipped separately. If shipped separately, the grading device container and its associated insulator container must be clearly marked with easy to read matching identification.

7.2.2 Prior to the insulator delivery, the manufacturer shall supply purchaser with documentation explaining the use of matching identification number grading ring installation, insulator lot numbers and insulator identification numbers.

8.0 DRAWINGS

Drawings for each type of offered insulator shall be submitted with the bid. The drawings shall have a minimum of two views with an appropriate scale. Each drawing shall clearly show the following dimensions (including manufacturing tolerances) and ratings:

- Connection Length
- Number of Sheds
- Shed Interspaces
- Shed Diameter and inclination angle
- Core Diameter
- Dry Arc Distance
- Leakage Distance
- Approximate Weight
- Low-Frequency Dry Flashover
- Low-Frequency Wet Flashover
- Critical Impulse Flashover Positive
- Critical Impulse Flashover Negative
- Switching Impulse Flashover/Withstand
- Specified Mechanical Load
- Routine Test Load
- Rod Material and Manufacture
- Housing Material and Manufacture
- End Fitting Material and Manufacture
- Cross-Sectional View of Insulator Unit with Dimensions
- Size and Dimension Details for Both End Fittings
- Insulator Description
- Manufacturer's Catalog Number
- Manufacturer's Drawing Number
- Grading Ring Dimensions and Orientation
- Thickness of Zinc Coating
- Marking
- Insulator Color

All drawings shall be approved by purchaser before fabrication begins.

9.0 DOCUMENTATION

The manufacturer shall submit a complete bid proposal to the purchaser including the following documentation:

- Insulator Unit Cost Information
- Applicable Drawings with Associated Information as Specified in the Bidding Documents
- Ultimate Strength of Insulator (SML Rating)
- Maximum Continuous Working Load Ratings of Insulators (RTL Rating)
- Warranty Information
- Certified Test Reports (as required in Specification and Bidding Documents)
- Applicable Deflection and Combined Loading Application Curves
- Documentation of Insulator Performance in Proposed Installation Environment
- Insulator Washing Requirements and Procedures, If any
- Grading Device Information
- Delivery Date and Location
- Packaging and Shipping Details
- Special Application and/or Design Details
- Handling, Installation and Maintenance Details

DATA SCHEDULE
Composite Insulators

NTDC Tender/Purchase Order/Contract No.	Date:

Reference Clause of Specification	Description	A	B	C
3.0	APPLICABLE CODES AND STANDARDS			
	Applicable Industry Standards	*		
4.0	DESIGN REQUIREMENTS			
4.1	Insulator Type	Suspension Type		
4.2	Max. Diameter of Composite Suspension Insulator Weathershed (mm)	200		
	Type of End Coupling			
4.3	Ratings			
4.3.1	Nominal Length of Insulator (mm)	*		
	Min. Leakage Distance (mm)	*		
	Specified Mechanical Load 'SML' (kN)			
	Routine Test Load 'RTL' (kN)	*		
	Dry Arcing Distance (mm)			
	Type of Suspension String (Single/Double I-String, Vee String)			
	Type of Tension String (Single/Double/Triple/Quad)			
4.3.2	Electrical Values			
	Nominal System Voltage (kV) 132kV/220kV/500kV			
	Power Frequency Dry Withstand (kV)	*		
	Power Frequency Wet Withstand (kV)	*		
	Dry Lightning Impulse Withstand, Positive (kV)	*		
	Dry Lightning Impulse Withstand, Negative (kV)	*		
	Wet Switching Impulse Withstand (kV)			
4.3.3	Max. RIV at 1000kHz with Line to Ground (l-g) Voltage as per Clause 4.3.3	100µV		
4.3.4	Visible Corona Voltage Level, kV	*		
4.3.5	Receding water angle	80° or more		
	Weight per Unit (Kg)			
4.4	Type of weathershed			
	Coupling class/type of insulator end fitting	*		
	Insulator weathershed material	Silicone Rubber		

DATA SCHEDULE

Composite Insulators

Reference Clause of Specification	Description	A	B	C
	Weathershed profile (Regular/Alternating)	Alternate Weathershed		
	Min. sheath thickness over the core (mm)	>3		
	Min. silicone content of sheath-weathershed	≥30% By weight		
	Insulator core material	*		
	Core diameter (mm)	* (Φ24mm for 500kV)		
	Glass content in core (% by Volume)	>60		
	Insulator Fabrication Process (Molded/Modular/LSR)	*		
	Water washing pressure withstand	3800kPa		
	Attachment of Insulator End Fittings	Compression /Injection mold		
	Material of Insulator End Fittings	*		
	Material of Grading Device	*		

'A'– Purchaser Specified Data/Parameters
'B'– Bidder/Supplier/Manufacturer/Contractor Proposed Data/parameters
'C'– Remarks supporting the proposed deviation in Column B
(*)– Data/Parameters to be provided/proposed by the Bidder/Supplier/Manufacturer/Contractor in Column

DATA SCHEDULE

Composite Insulators

I: ADDITIONAL TECHNICAL INFORMATION OR FEATURES TO BE FURNISHED BY PURCHASER

II: ADDITIONAL SUPPLEMENTARY DATA OR FEATURES PROPOSED BY BIDDER/SUPPLIER/ MANUFACTURER/CONTRACTOR

III: OTHER PARTICULARS TO BE FILLED UP BY BIDDER/SUPPLIER/MANUFACTURER/ CONTRACTOR

	Actual Manufacturer of Equipment/Material	Bidder/Supplier/Contractor
Name of the Company Location and Address		
Name and signature of Authorized Representative and Date		
Official Seal/Stamp of the Company and Date		

ANNEXURE-I

A. ELECTRICAL SYSTEM PARTICULARS

500KV LINES

i.	System Voltage	500kV
ii.	Maximum Voltage	550kV
iii.	BIL (Max)	1550kVp
iv.	BSL (Max)	1175kVp
v.	Power Frequency Withstand Voltage (wet)	680kVrms
vi.	Min. Corona Extinction Voltage at 50Hz under Dry Condition	$346kV_{l-g}$
vii.	Short Circuit Level in 1 second	63kA

220KV LINES

i.	System Voltage	220 kV
ii.	Maximum Voltage	245 kV
iii.	BIL (Max)	1050 kVp
iv.	Power Frequency Withstand Voltage (wet)	460 kVrms
v.	Min. Corona Extinction Voltage at 50Hz under Dry Condition	$160kV_{l-g}$
vi.	Short Circuit Level in 1 second	40 kA

132KV LINES

i.	System Voltage	132 kV
ii.	Maximum Voltage	145 kV
iii.	BIL (Max)	650 kVp
iv.	Power Frequency Withstand Voltage (wet)	275 kVrms
v.	Min. Corona Extinction Voltage at 50Hz under Dry Condition	$100kV_{l-g}$
vi.	Short Circuit Level in 1 second	31.5 kA

B. SERVICE CONDITIONS

Unless otherwise specified, the equipment/material shall be suitable to operate under the typical system parameters as stated below:

i.	Altitude above Mean Sea Level (MSL)	
ii.	Ambient Temperature:	
	a. Minimum	
	b. Maximum	

	c. Monthly average of the hottest month	
	d. Yearly average	
iii.	Ambient ground temperature	
iv.	Max. relative humidity	
v.	Contamination level:	
	a. Equivalent Salt Deposit Density (ESDD)	
	b. Non-Soluble Salt Deposit Density (NSDD)	
vi.	Average rainfall per year	
vii.	Design wind velocity	
viii.	Approximate highest density solar radiation averaged over the summer months	
ix.	a. Isokeraunic level (Average)	
	b. Isokeraunic level (Maximum)	
x.	Maximum Earthquake frequency/severity	
xi.	Climate conditions	

SPECIFICATION FOR OPGW & JOINT BOXES

SPECIFICATIONS OF

24/36/48-FIBER OPTICAL FIBER GROUND WIRE (OPGW), OPGW INSTALLATION HARDWARE, 24/36/48-FIBER FIBER OPTIC CABLE (FOC), OPTICAL FIBER JOINT BOX (OJB), OPTICAL FIBER TERMINATION BOX (OTB) AND OPTICAL FIBER DISTRIBUTION FRAME (ODF) RACKS & CABINET

Contents

1. GENERAL

The telecommunication media shall provide the means for transportation of information from points of origin to various destinations. The information to be carried by the telecommunication media for the NTDC power transmission network shall comprise:

- Data Communication between RTUs / SAS and SCADA / EMS at NPCC.
- Speech Communication for Operation & Control between Grid Stations and NPCC.
- Tele-protection signaling between two stations at both ends of transmission line.

This specification covers the design, manufacture, factory testing, type testing, supply, storage at site, installation, site testing & commissioning of Optical Fiber Ground Wire (OPGW) & Optic Fiber Link (end to end), hardware & fittings for OPGW installation, outdoor Optical Fiber Joint Boxes (OJBs) for OPGW-OPGW jointing, outdoor Optical Fiber Joint Boxes (OJBs) OPGW-FOC jointing, outdoor & underground Fiber Optic Cable (FOC), underground/outdoor Optical Fiber Joint Boxes (OJBs) for FOC-FOC jointing, indoor Optical Fiber Termination Boxes (OTBs), Optical Fiber Distribution Frame (ODF) Racks (Fiber Optic Patch Panel) & ODF Cabinet / Cubicle and accessories to establish optical fiber links needed to implement fiber optic communication links (SDH/PDH) and differential relays communication links for above mentioned requirements.

As the quality of OPGWs, FOCs, OJBs, OTBs, ODFs and associated hardware & accessories is critical to reliable optical transmission system performance, these products shall be produced with ISO-9001 certified production facilities and quality control system shall be applied on the whole process from product design to packaging. The bidder / contractor shall include ISO-9001 certificates of the manufacturers of these products in the bid as well as in material approval submittals to support this requirement.

The bidder / contractor shall submit type test certificates and reports for OPGW, FOC, OJB, OTB, ODF and associated hardware & accessories conducted by NTDC approved international laboratories to verify and establish related design characteristics. The bidder / contractor shall propose / offer all of required equipment, material, hardware & accessories as per NTDC's approved vendor list.

The bidder / contractor shall submit full constructional details and technical data of the offered OPGWs, FOCs, OJBs, OTBs, ODFs and associated hardware & accessories with the bid/documents. Duly filled technical data sheets (comparison of data) of each of the offered & required items must be provided in the bidding document by the bidder. The bidder/contractor shall also submit supporting engineering drawings, diagrams, sketches & original technical documents/brochures of each of proposed item.

2. STANDARDS

Standards included in this section shall in general conform to the following list. The bidder may propose alternative codes and standards provided it is proven to be an equivalent degree of quality & compatibility as the referenced codes and standards.

Unless otherwise specified herein, the contractor shall conform to the applicable requirements of the latest revisions of the following standards or equivalent as approved by the NTDC-Telecom.

ITU-T G.652:	Characteristics of a single-mode optical fiber and cable.
ITU-T G.655:	Characteristics of non-zero dispersion-shifted single-mode optical fiber and cable.
ASTM B 415, B 416:	Standard Specifications for Hard-Drawn Aluminium-Clad Steel Wires.
ASTM B 398:	Standard Specification for Aluminium-Alloy 6201-T81 Wire for Electrical Purposes.
IEEE Std 1138:	Construction of Composite Fiber Optic Overhead Ground Wire (OPGW) for use on Electric Utility Power Lines.
IEC 60793:	Optical Fibers Generic Specification & Product Specification.
IEC 60794:	Optical Fiber Cables.
EIA 598A:	Optical Fiber Cable Color Coding.
IEC 68-2-14:	Joint Boxes/Hardware Fittings.
EN 60529:	Protection Class of Cabinets/Cubicles.
IEC 61300-2-36:	Fiber Optic Interconnecting Devices & Passive Component - Basic Test and Measurement Procedures – Part 2-36: Tests-Flammability (Fire Hazards).

3. SPECIFICATIONS OF 24/36/48-FIBER OPTICAL FIBER GROUND WIRE (OPGW), OPTICAL FIBER JOINT BOXES (OJBS)/ENCLOSURES AND OPGW INSTALLATION HARDWARE & FITTINGS

3.1 24/36/48-Fiber Optical Fiber Ground Wire (OPGW)

The OPGW shall be designed to withstand the specified short circuit current and design of the overhead power transmission line, which is based on the System Characteristics and Fault Levels. Further details and specific data are described below and given in the specific works Data sheets of these specifications.

(a) Material and Workmanship

The material(s) used for the manufacturing of the OPGW shall be of highest grade free from defects and imperfections conforming to the requirements of the latest issue of the relevant standards.

The materials used shall be:

- Aluminum clad steel (ACS) wires for inner conducting layer (armor).
- Aluminum alloy (AA) wires for outer conducting layer (armor) if more than one conducting layer are used.
- Glass material for optical fibers.

- Aluminum extruded central hollow tube housing loose plastic buffer tubes.
- Polybutylene terephthalate for loose buffer tubes housed in central hollow metallic tube. Optical fibers are housed in the loose plastic buffer tubes.
- FRP (Fiberglass-Reinforced Plastic material) Strength Member
- Thermal Barrier
- Moisture proof and hydrogen absorbent gel.

Proper arrangement shall be made for the provision of corrosion prevention material and suitable filling compounds as hydrogen absorbing gel in the offered OPGW. The bidder shall provide details in this regard.

(b) Construction

The OPGW shall comprised of:

- Fiber optic units designed to house and protect the optical fibers from damage by means of forces such as crushing, bending, twisting, tensile stress and moisture.
- Metallic Unit - An outer metallic part (armor) designed to function as the conventional shield wire and additionally to protect the fiber optic unit.

The fiber optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibers from degradation in optical attenuation or mechanical damage to any of the OPGW components due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault currents as well as environmental effects that may produce hydrogen.

The OPGW must have such mechanical and electrical features so as to be strung on HV & EHV overhead transmission lines towers. The OPGW shall be greased to withstand heavy corrosion and chemical evaporation.

The total OPGW length shall be determined by the bidder / contractor taking into account for sag, splices, drops at the joint locations, extra length fibers & tubes to be kept inside joint boxes. In addition extra length shall also be kept rolled / coiled outside each of optical fiber joint boxes (for OPGW – OPGW jointing) at intermediate OHL towers and outside the terminal optical fiber joint boxes (for OPGW – FOC jointing) at the overhead power transmission line (OHL) gantry structures on both ends of the OPGW inside the substations to allow joint box / enclosure to move to ground for post-installation drum test, jointing, splicing, re-splicing purpose etc. The reserve length of fiber against the linear length of the OPGW shall be such that when the OPGW is subjected to 100% UTS (ultimate tensile strength) and reaches the breaking point, optical fibers must not break.

(c) Fiber Optic Unit (24/36/46-fibers):

The fiber optic unit shall comprise of central hollow metallic (stainless steel / aluminium) extruded tube housing the buffer tubes made of appropriate material (polybutylene terephthalate) to withstand temperatures of 200°C under short-circuit current condition without continuous degradation. The hollow metallic tube housing the buffer tubes shall be placed in the center of the inner / outer layers stranded metallic wires (armour) in order to be protected from external mechanical forces and electrical disturbances. The central hollow metallic tube housing the plastic buffer tubes, shall ensure protection against

tensile, twisting and crushing forces on the plastic buffer tubes and optical fibers. The plastic buffer tubes along with water swell-able yarns should be helically stranded around a non-metallic support member (FRP strength member) inside the center of the hollow metallic extruded tube filled with hydrogen absorbent gel and the optical fibers shall be loosely housed in the plastic buffer tubes filled with waterproof gel to prevent water penetration and protection against friction. Thermal tape (thermal barrier) should be applied around the whole group of plastic buffer tubes to provide protection of the buffer tubes from sudden increases in temperature due to fault current and lightning strikes. Water swell-able tape shall also be applied below the thermal tape.

Number of plastic buffer tubes & numbers of optical fibers per buffer tube to be provided in 24-fiber, 36-fiber & 48-fiber OPGWs are mentioned below:

OPGW	Nos. of Plastic Buffer Tubes	Nos. of Optical Fibers per Buffer Tube (equally distributed)
24-fiber OPGW	3 or 4	8
36-fiber OPGW	3 or 4	12
48-fiber OPGW	4	12

Optical fibers shall be equally distributed among all of plastic buffer tubes.

All of fibers in each of buffer tube shall be distinguishable from each other in the same tube by means of colour coding in accordance with EIA-598A. Each of plastic buffer tube shall also be colour coded to distinguish each other in accordance with EIA-598A standard. The optical fibers and buffer tubes colours shall be stable during temperature cycling and shall not fade or smear on each other or in the gel-filling compound.

(d) Metallic Unit - Stranded Metallic Wires (Armour)

The fiber optic unit shall be stranded with Aluminium-Clad Steel wires (ACS). However, if more than one layer is used, Aluminium-Alloy (AA) may be used for the outer layer.

The basic construction shall have bare concentric lay stranded metallic wires. The stranded wires may be of multiple layers with a combination of various metallic wires within each layer. The wire strands shall be in close contact and the wires of strands shall be free of points, sharp edges, abrasions or other imperfections. The direction of lay shall be reversed in successive layers. The outer strands wires shall be designed to prevent bird caging, strained popping and unravelling during normal handling and installation.

The rated breaking strength of the completed OPGW shall be taken as sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the appropriate specified minimum tensile strength. When determining the tensile strength, a safety factor of 2.5 shall be applied.

(e) Sag and tension limits:

Physical design of the OPGW for installation on overhead transmission line towers shall have sag and tension characteristics similar to the 9.78mm diameter, extra high strength, 7 (seven) strands, galvanized steel overhead shield wire for the spans.

(f) 24/36/48-fiber OPGW Characteristics:

From the environmental point of view, the OPGW will be exposed to a harsh environment that needs to be taken into consideration:

- Outdoor temperature range (Operating): -20°C to +80°C
- Max. Summer relative humidity: approaching 100%
- Sand and windstorms.

If calculation for the solar effect on the metal surface proves higher temperature range, the same shall be considered in the OPGW design. The OPGW should be capable to withstand temperature up to +200°C resulting from the rated fault current (for 1 sec) or during lightning without degradation of performance. The contractor shall take these atmospheric constraints in to account to guarantee at least 35 years of service life for the OPGW cable. In this respect, the bidder/contractor shall provide type test report & certificate of the OPGW from NTDC's approved laboratory/agency proving that the proposed OPGW cable complies with IEC accelerated aging test in the above conditions.

The main characteristics of the 24/36/48-fibe OPGW cables shall be as listed below:

OPGW Characteristics	24-fiber OPGW	36-fiber OPGW	48-fiber OPGW
Number of Fibers	24	36	48
No. of plastic buffer tubes	3 to 4	3 to 4	4
No. of fibers per buffer tubes (equally distributed)	8	12	12
Central hollow metallic tube (housing the buffer tubes)	Aluminum extruded tube	Aluminum extruded tube	Aluminum extruded tube
Outer diameter (nominal)	≤ 12.5 mm	≤ 13 mm	≤ 13 mm
Breaking load	≥ 7000 kg	≥ 8000 kg	≥ 8000 kg
Nominal weight:	≤ 465 Kg/km	≤ 475 Kg/km	≤ 480 Kg/km
Short circuit current for 1 sec.	≥ 6 kA for temp. rise from 20° C to 200° C	≥ 7 kA for temp. rise from 20° C to 200° C	≥ 7 kA for temp. rise from 20° C to 200° C
DC resistance at 20°C	≤ 0.75 ohm/km	≤ 0.7 ohm/km	≤ 0.7 ohm/km
Minimum bending radius (without fiber damage) - Operating	≤ 220 mm	≤ 250 mm	≤ 250 mm

(g) Fiber Characteristics

The fiber core shall be single mode (SM) type made of high grade ultra-pure fused silica glass for operation at wavelengths of both 1310nm and 1550nm and conform to ITU-T G.652 recommendation with data transmission data up to 2.5 Gbits/s.

The fiber shall be suitable to operate safely and within the specifications under the prevailing environmental conditions, e.g.:

- Storage temperature range: -10°C to +70°C
- Installation temperature range: -10°C to +70°C
- Operating temperature range: -20°C to +80°C
- Max. Summer relative humidity: approaching 100%
- Sand and windstorms.

If calculation for the solar effect on the metallic unit surface proves higher range, the same shall be considered in the OPGW design. The fiber shall withstand temperature up to 200°C resulting from the rated fault current (for 1 sec) or during lightning without degradation of performance.

The main features of the optical fiber shall be as follows:

Fiber type	Zero dispersion un-shifted single mode according to ITU-T G.652
Wavelength	1310nm and 1550nm
Max. attenuation	≤ 0.35dB/km at 1310 nm ≤ 0.20 dB/km at 1550nm
Max. splicing loss	0.1 dB
Max. end-connector loss	0.5 dB
Core diameter	9/10μm ± 0.5μm
Cladding diameter	125μm ± 2μm
Max. concentricity error	1μm
Max. cladding non-circularity	2%
Max. chromatic dispersion:	< 3.5 ps/nm.km at 1310nm < 20 ps/nm.km at 1550nm
Cut-off wavelength	< 1260 nm
Mode field diameter	9.5 μm ± 0.6
Operational temperature range	-20 to +80°C
Optical transmission speed	up to 2.5 Gbits/s

Inside the buffer tube, the reserve length of optical fibers shall be at least 0.45% against the linear length of the complete OPGW to prevent the optical fibers from coming under stress. To prove this, a sample of at least 80 m shall be pulled up to endurance tensile strength while a continuous optical measurement of fiber length and attenuation is done simultaneously.

(h) Ending Rules

Waterproof & heat resistant end seals shall be fixed on the OPGW ends of each drum to ensure water-tightness immediately after manufacturing, reeling and FAT of the respective OPGW lengths. The outer end shall be fitted with a watertight head compatible with cable pulling. Caps (material and implementation) shall comply with applicable standards. These end seals shall not be removed until start of OPGW drum test and splicing / jointing of two sections of OPGW and / or OPGW / FOC in the OJB at OHL towers and / or at the gantry structure inside the substation.

(i) OPGW Drums

The OPGW shall be delivered to erection sites on drums of standard material reels. The drums should contain agreed lengths of OPGW, which shall not generally be less than 5000 m depending upon the OPGW stringing schedule. The barrel diameter of the shipping drums shall be large enough at least 40 times the outer diameter of the OPGW to prevent damage to the OPGW during reeling / unreeling. Wooden lagging or other suitable means of protection shall be applied to the drum to prevent damage to the OPGW during shipment & storage. The drums / reels will be non-returnable. The OPGW ends shall be sealed and fasten tightly using shrinking caps and a protective wrap should be applied over the outer layer of the OPGW on the reel / drum. For test purpose, a length of at least 4 meters of inner OPGW end shall be accessible without removing wooden lagging. This length shall be securely fastened and protected during shipment and handling.

All of OPGW drums shall be open and accessible during the FAT of OPGW (whole lot).

OPGW drums shall be fitted with securely attached, unalterable identification plate of approved format bearing the following information:

- Supplier's name: _____
- Manufacturer's name: _____
- Contract number: _____
- Project name: _____
- OPGW Type: _____
- Measured Attenuation coefficient of OPGW: _____
- Sr.No. & Drum No.: _____
- Length of OPGW on the drum: _____
- OPGW manufacturing date: _____
- Tension-torque value: _____
- Arrow indicating rolling direction: _____
- Position of the OPGW nose: _____
- Weight of OPGW drum: _____

3.2 Live Line Installation of OPGW

(a) Installation

The live line installation of OPGW shall be accomplished by the following procedure if required:

- Initial Preparation
- Installation of supporting rollers / guide rope and mobile unit.
- OPGW stringing.
- Turnover and sagging.
- Retrieval of support rollers, ropes, mobile unit and the existing ground wire.
- Jointing and testing

The contractor shall arrange all the installation equipment / material / hardware / tools / accessories for the live line installation of new OPGW to replace the existing Ground Wire and / or old OPGW. This shall include but not be limited to:

- Guide rope
- Pulling rope
- Recovery mechanism
- Mobile unit
- Tools and measuring equipment

The above materials shall be under the contractor's ownership and the contractor may be required to handover the above equipment / material / tools to NTDC after completion of the work under the contract.

Installation of the OPGW shall be carried out using approved tools & equipment. The contractor shall ensure that method used for installation of the OPGW shall not cause any damage to the OPGW including metallic unit, buffer tubes & fibers.

Before start of live line installation of the OPGW, the contractor must ensure the following:

- All of design drawings & documents for the OPGW links are in "Approved" status. This also included design drawing of OPGW / FOC link block diagram, fiber joint boxes types & location diagram, optical fiber joint design, optical fiber configuration drawing etc.
- All of submittals for approval of the required OPGW, equipment, material, hardware, tools, accessories etc related to live line installation of the new OPGW are in "Approved" status.
- Method Statement for live line dismantling of existing Ground Wire or old OPGW and live line installation of the new OPGW shall be submitted well in time with "Approved" status.

Survey & getting necessary information about local conditions of the overhead transmission line & towers and environment / surface condition around them required to prepare and submit the complete OPGW links design proposal & method statement for the OPGW link installation, shall be the contractual responsibility of the bidder/contractor.

The OPGW shall be earthed to the tower steel work at each tower using approved clamps and bonding leads. No mid-span joints shall be allowed in the OPGW. All joints shall be performed in optical joint boxes (OJBs) located above anti-climbing devices in the overhead transmission line towers.

The contractor shall be responsible for any delay occurs in completion of the live line installation of new OPGW because of incomplete submission or delay in submission of above mentioned drawings and documents.

(b) Safety and Security

The contractor shall ensure the complete arrangements for safety and security of personnel and ensure the equipment / tools / material etc. are in place before start of live line installation of the OPGW. In particular, following measures shall be taken:

- Working conditions on tower and ground shall be fully investigated and recorded.
- Safety gadgets for the personnel shall be made available.
- Warning flags shall be fixed.
- Electrical grounding shall be ensured.
- Clearance between live line and installation equipment shall be ensured at all times.
- Safety evaluation shall be made by simulation of:
  - Electrostatic induction.
  - Electromagnetic induction.
  - Dry band arcing.
  - Dynamic sag/tension during installation.

3.3 Outdoor Optical Fiber Joint Boxes (OJBs) for OPGW / OPGW / FOC Joints

Outdoor Optical Fiber Joint Boxes (OJBs) shall be provided to protect fiber splices of OPGWs, Underground FO Cables and Approach FO cables from all construction and working stresses likely to deteriorate their characteristics. Each outdoor OJB shall be supplied with joint enclosure, complete mounting hardware, gland plates & glands with fittings to secure & seal the OPGWs / FO cables in the gland plates, cable holders, cleats to secure the OPGWs / FO cables fitted inside the joint box, splicing sleeves, heat shrinking protective tubes, splice holders, organizers / fittings and internal splice cassettes & optical fiber splice kits to accommodate the required number of splices for permanent optical fiber joint of OPGWs/FO cables. All jointing materials / accessories shall be sufficient for at least 1.2 times the number of required splices / fibers. The splice loss shall not be more than 0.05 dB. Attachment of OPGW or approach Fiber Optic Cable (FOC) ends and splicing of all of fibers in the OJBs as per approved optical fiber configuration drawings shall be the integral part of supply & implementation of Optical Fiber Joint Boxes (OJBs).

The OJBs shall be fully equipped for splicing/jointing/interconnection of all optical fibers of two to six nos. of 24-fiber and/or 48-fiber OPGWs & FOCs (as required at different locations for OPGW/FOC links/network configuration). Operating temperature range for OJBs shall be -20° to +80°C.

The optical fiber joint boxes design shall ensure only bottom entry of OPGWs & FO Cables, quick removal of box cover giving access to fiber splices. Sufficient fiber length should be left loose within the OJB box allow re-splicing/repair of fiber-splices at least four times during transmission line's working life.

The OJBs shall be weatherproof with protection Class IP65 made of non-corrosive aluminium alloy or stainless steel and shall be fitted with a bolted & lockable lid on the bottom side with OPGWs / FO Cables access through watertight glands on bottom side.

Each outdoor OJB shall be capable of hermetically sealed after jointing and hermetically resealed after reopening and reclosing. The joint boxes / enclosures shall be securely clamped to towers /gantries.

The OJBs shall be located & installed as per approved location layout drawings of the entire OPGW & FOC link.

The contractor shall submit detailed material approval documents for OPGW, FOC, OJBs and associated hardware / accessories in consolidated form for review & approval. The contractor shall also submit design drawings with related technical detail and concerned documents for the complete OPGW & FOC links for review / approval as required by NTDC-Telecom.

Name plates of made of approved waterproof material and with approved format (in English language) giving important information shall be attached / fixed to each optical fiber joint box (OJB) which shall have embossed characters. The nameplate shall have the following information:

- Type of Optical Fiber Joint Box: _____
- Owner: _____
- Consultant: _____
- Manufacturer name: _____
- Year of manufacture: _____
- Contract No.: _____
- Project: _____
- Optical Fiber Joint Box Location / Tower No.: _____
- OPGW in OJB Direction-1 (Station Name & fibers) _____
- OPGW in OJB Direction-2 (Station Name & fibers) _____
- OPGW in OJB Direction-3 (Station Name & fibers) _____
- OPGW in OJB Direction-4 (Station Name & fibers) _____
- Name of Station & Direction of OPGW terminated in OJB inside Substation: _____
- OPGW Link Length : _____

Identification labels of weatherproof material with embossed characters (of approved format) shall also be provided on each of OPGW, underground FO Cable & Approach FO cable (AFOC) at the entry points of each of optical fiber joint box (OJB).

In order to allow optical fiber joint box / enclosure to move to ground for purpose of jointing / splicing of fibers, suitable extra lengths (about 10 meters) of each of OPGW & FO Cable shall be kept coiled outside the terminal OJB (for OPGW-FOC joint) inside the OHL gantry structure in the substations at both ends of the OPGW link and dressed using approved clamps & hardware. Moreover, extra lengths of each OPGW (20 meters or suitable length as required & approved) shall be kept coiled on both directions of each of intermediate OJB (for OPGW-OPGW joint) fixed & dressed inside the overhead power transmission line (OHL) towers on the OPGW link using approved clamps & hardware.

The contractor shall provide labels of approved material, contents & format on each of extra-length OPGW & FOC coils at each of OJBs on the entire OPGW link.

Types of Outdoor Optical Fiber Joint Boxes (OJBs):

Type A: Optical fiber joint boxes (OJBs) on OHL used to connect/joint two sections of OPGW anchored on a tower (OPGW-OPGW joint). These will be installed at a suitable / approved height about in middle portion of OHL towers or portal structure along OHL tower body, above the anti-climbing device. A spare stripped off length (approx. 1.5m) of fibers of OPGW/FOC shall be left inside the OJBs to repeat/remake faulty splices.

Type B: This type of optical fiber joint boxes (OJBs) is installed on 500/220/132KV Overhead Power transmission Line (OHL) Gantry inside the substation to interconnect/joint the optical fibers of OPGW(s) to Approach Fiber Optic Cable (AFOC) or external underground fiber optic cable (UGFOC) within the substation (for OPGW-FOC joint). This type of OJB shall also be suitable to install on 500/220/132KV Overhead Transmission Line Tower/Pole to join the optical fibers of OPGW to underground fiber optic cable (UGFOC) on the route of OHL & High Voltage Power Cable between the two substations/sites. The type-B OJBs shall be in general similar to type A, except for the cable entry and shall be installed at a suitable/approved height about in middle portion of OHL gantry/towers. A spare stripped off length (approx. 1.5m) of fibers of OPGW/FOC shall be left inside the OJBs to repeat/remake faulty splices.

Type C: This type of optical fiber joint boxes (OJBs) is used to connect/joint four sections of the OPGW fibers (OPGW-OPGW-OPGW-OPGW) or three sections of the OPGW fibers (OPGW-OPGW-OPGW) or two sections of the OPGW fibers with one/two underground fiber optic cables (OPGW-OPGW-FOC-FOC). These will be installed at a suitable / approved height in middle portion of OHL towers or support structure (tower / gantry), above the anti-climbing device. A spare stripped off length (approx. 1.5m) of fibers of OPGW / FOC shall be left inside the OJBs to repeat/remake faulty splices.

Type D: This type of underground optical fiber joint box is installed in man-hole/trench or buried underground to connect/joint/interconnect two/three/four sections/links of underground fiber optic cables (FOCs). These OJBs will be located in the man-hole/trench or buried underground at suitable & approved sites/locations on the route of High Voltage Power Cable(s) sections between the two substations. These OJBs shall be similar to above type except for the connection arrangement and additional protective casing/enclosure of appropriate protection class to install in man-hole/pit/trench or buried underground. A spare stripped off length (approx. 1.5m) of fibers of each of FO Cables shall be left inside the OJBs to repeat / remake faulty splices. Extra lengths (at least 5 meters) of each of the underground/armoured fiber optic cable (FOC) shall be kept with the OJB inside the man-hole/pit/trench to bring the OJB out from the man-hole/trench for splicing/jointing of the fibers.

The bidder/contractor must provide duly filled technical data sheets (comparison of data) of each type of the offered & required OJBs/items in the bidding document along with the supporting engineering drawings, diagrams, sketches & original technical documents/brochures of each of each type OJB.

The Contractor shall also design and supply the supporting devices made of galvanized steel to install joint boxes on the galvanized steel towers /terminal structures and of approved material for underground installation for FOCs. Fasteners /clamps for installation of the supporting devices on the towers/terminal structures/man-hole/trench and the joint boxes on the supporting devices shall be supplied as integral part of the optical fiber joint boxes. Galvanizing on the structural steel shapes of supporting device shall conform to ASTM A123 latest edition with average weight of zinc coating as 610gm/m2 and on the fasteners shall conform to ASTM A153 (latest edition) with average weight of zinc coating as 305gm/m2. One supporting device for each joint box will be supplied as per requirement for installation on the gantry/tower/trench/man-hole. Design drawings and materials documents of OJBs and the supporting devices / hardware / accessories shall be subject to approval of the NTDC-Telecom.

3.4 Optical Fiber Splicing

The splicing of the Optical fibers should be carried out in the transit joint boxes and terminal joint boxes by the contractor's well-trained technical personnel recommended by the manufacturer of OPGW & FOC. The contractor shall provide all required splicing equipment, instruments, tools and test equipment recommended by the Manufacturer of PPGW/FOC for the execution of optical fiber splicing /jointing, termination & testing as per approved optical fiber configuration drawings. Fusion splicing shall be applied to join the optical fibers in a neat & clean environment. Before splicing, the fiber ends shall be cleaned & prepared using tools and methods recommended by the manufacturer of OPGW/FO Cable. All of splices shall be properly supported within the joint/termination box in such a way that removing & replacing of the splices in support device without risk of damage to the splice or fiber shall be possible. All the test equipment must have valid calibration certificate.

Measured value of splice loss shall not be more than 0.05 dB. Proper numbering shall be provided on each fiber core to facilitate identification in accordance with approved splicing configuration drawings and optical fiber configuration drawings of the OPGW/FOC link.

3.5 Hardware and Fittings for OPGW

(a) General

All of mounting hardware /accessories /fittings and joint boxes shall be supplied for a complete operational OPGW/FOC link required as per design and actual status at site.

All hardware /fittings /accessories shall be designed in such a way that no degradation of the optical transmission in the fibers of the OPGW/FOC will occur under all service conditions & harsh environment.

In order to ensure the compatibility of the required fittings / hardware for the OPGW, the contractor shall arrange to perform the compatibility tests proposed by the OPGW

manufacturer at the OPGW manufacturing premises subject to the approval by NTDC-Telecom.

The required hardware / accessories / fittings / material etc., shall in general include, but not be limited to, tension set for jointing tower, tension set for non-jointing tower, tension set for terminal tower, vibration dampers, ground wire bracket, turn buckle, parallel groove clamp, fastening clamp, suspension set, armour grip suspension clamp, angle tower hardware, dead-end tower hardware, earth bonding leads, clamps for vertically mounting OPGW on tower steel work, clamps & hardware for fixing the coiled extra length of OPGWs / FO Cables inside tower / gantry structure and the respective joint boxes.

(b) Tension assembly

The tension assembly shall consist of a line guard and a pre-formed dead end, which is placed on the line guard. The line guard shall be laid in the opposite direction of the outer layer of the OPGW and the dead end must be laid in the opposite direction of the line guard. The length of line guard shall be sufficient to install vibration dampers, if necessary. It shall protect the OPGW against concentrated radial forces in the region of contact between the dead end and the OPGW. All helical rods shall be made of ACS.

The distance from the center of the take-off hole to the edge of the plate will be 32mm. The thickness of the strain plate will be 16mm.The assembly shall have provisions for attachment of pulling fittings for erection and maintenance.

The assembly shall be free to swing so that the clevis will stay in line with the OPGW when the OPGW approaches the tower at any horizontal angle within ±30° from the longitudinal direction of the transmission line and at any vertical angle between the horizontal and 20° below the horizontal.

The general arrangement of tension assemblies for single and double tension set for OPGW shall be as per proven standards and as approved by NTDC during material approval & design stage.

(c) Suspension Assembly

At suspension points, armour grip suspensions must be used exclusively. The clamp body shall be of Aluminium alloy, which shall preferably be forged. The rod material shall be drawn Aluminium alloy.

The assembly of the suspension clamp and its hanger shall be able to swing freely in both the longitudinal and transverse directions up to an angle of 70° with the vertical.

The general arrangement for suspension set for OPGW shall be as per proven standards and as approved by NTDC during material approval & design stage.

(d) Vibration dampers

The OPGW shall be protected from Aeolian vibrations. For this purpose the Contractor shall conduct a vibration study based on the self-damping measurements of offered OPGW, span length distribution, height of OPGW above ground level, local atmospheric condition (i.e. wind velocities, temperatures etc.), topography and design tension limits

and shall calculate and recommend the number, type and locations of vibration dampers for different span sizes.

The vibration dampers shall be of the stock bridge type having clamp compressed or cast onto the steel messenger wire between the weights. Damper weights shall not be cast on the messenger strand. All ferrous components shall be protected by zinc coating and shall be according to ASTM A153 and ASTM A239 (latest edition). The damper clamp shall be designed in such a manner that moisture cannot accumulate anywhere in the damper. Each damper weight shall be provided with drain hole. Breakaway bolts shall be provided for the dampers.

General arrangement for stock bridge vibration damper shall be as per proven standards and as approved by NTDC during material approval & design stage.

(e) OPGW attachment clamps

Attachment clamps to hold the OPGW to the tower at splicing locations shall be made of hot dip galvanized steel and shall be provided as per proven standards and as approved by NTDC during material approval & design stage.

The installation of OPGW on towers at splicing locations shall be as shown shall be as per proven standards and as approved by NTDC during material approval & design stage.

4. 24/36/48-FIBER FIBER OPTIC CABLE (FOC) AND FOC INSTALLATION

4.1 Underground 24/36/48-fiber Fiber Optic Cable

(a) General

The fiber optic cable shall be designed in accordance with the latest issues of IEC & ITU-T standards & other related standards as per NTDC-Telecom's approval to withstand all prevalent environmental conditions, stretching, bending, & crushing forces, vibration effects including the effects of high electric and magnetic fields produced in proximity of live power cables.

A service life of at least 35 years in the working conditions & in installation environment prevailing in NTDC's power system /network is required with safety, health and environmental requirements compliance. The type test report of approved laboratory as evidence to support the FO cable manufacturer's claim in this respect shall be submitted with the bid by the bidder.

(b) Fiber Optic Cable Type:

The fiber optic cable shall be of the single mode type equipped with at least 48 optical fiber cores (or as required/approved) complying with ITU-T recommendation G.652. Optical fiber cores made of ultra-pure fused silica glass shall be loosely housed in plastic buffer tubes. It shall have low dispersion values for the entire possible wavelength range above the cut-off wavelength of the cabled single-mode fibers, which should not be more than 1260 nm.

The FO cable shall be suitable for indoor and outdoor use, either directly buried in the ground or laid in ducts or on cable ladders /trays in the outdoor /indoor trenches. In either case, the fiber optic cable(s) shall be laid in PVC pipes approved by the NTDC-Telecom.

FO cable of 48-fibers shall be supplied unless otherwise mentioned in the scope of work

(c) Fiber Optic Cable Requirements

- **Water-tightness**

The cable shall be fully moisture-resistant and meet the longitudinal water-tightness test requirements.

- **Electrical withstand**

As there exists potential danger due to occurrence of any electrical fault or leakage currents in electrical environment, the optical fiber cable must be non-metallic.

- **Mechanical withstand**

The cable shall suitably withstand the mechanical radial stresses and shall be protected against rodents and termites. The crush resistance shall be at least 2kN/10cm.

- **Temperature withstand**

The operating temperature range shall be -20°C to +80°C and the cable shall be suitable for operation in tropical climate with humidity approaching 100%.

(d) Fiber characteristics

Identical to those given in section 3.1. (g) of "OPGW characteristics".

(e) FO Cable Construction

Metal free fiber optic cable with loose buffer tubes construction, minimum strain configuration, which provides protection from external forces and possesses high tensile strength /resistance to crushing (closer to armoured FOC), shall be provided. The optical fibers shall be loosely housed inside plastic buffer tubes filled with water blocking gel to protect the fibers from the ingress and propagation of moisture. The buffer tubes shall be helically wound over the non-metallic central strength member with jacket. The buffer tubes shall be sufficiently strong to hold their shape and provide protection for the optical fibers against deformation and friction etc. Water blocking gel compound filled in the buffer tubes as well as in the interstices between these buffer tubes, shall not freeze or drip out over the specified temperature range. The water blocking gel/compound shall not be detrimental to the other fiber optic cable components and shall not cause swelling of the buffer tubes. The construction of the cable shall be such as not to allow water /moisture penetration either longitudinally or axially.

The cable construction shall comprise a dielectric central strength member surrounded by loose buffer tubes and fillers covered by moisture-resistant wrapping. The interstices among the loose tubes shall be filled with water blocking gel compound. The wrapping shall be covered with thermoplastic sheath surrounded by aramid or glass yarn

reinforcement. Anti-rodent protection shall be provided around the reinforcement layer by means of glass tape. The outer jacket of the cable shall be made of rugged non-metallic material of thickness not less than 1.5mm and covered with anti-termite coating.

Armoured fiber optic cable of approved design shall be suppled in the it is required to be laid underground through trenches/concrete ducts on the route of High Voltage Power Cable(s) sections between the two substations as per design & scope of work.

The fiber optic cable shall be designed so that the optical fibers shall be free of longitudinal strain under all conditions of specified load and temperature. An extension of 0.6 percent will not produce strain in the fibers and not result in an increase in attenuation.

The fiber cores shall be made of ultra-pure fused silica glass suitable for operation at 1310 and 1550 nm wavelengths. Outer sheath of the FO cable shall be capable of withstanding direct rays at the termination gantries etc without any detrimental effect.

The number of fibers inside any one plastic loose buffer tube shall be in general eight (8) but not more than twelve (12) and nos. of plastic buffer tubes shall be six (6) or four (4) as advised/approved as per requirement of optical fiber configuration. Each tube and fiber shall be color coded to be distinguishable from the other in accordance with EIA-598A standard.

The design shall be generally as per the latest versions of recommendations and specifications made by ITU-T and IEC and/or equivalent/other standards as approved by the NTDC.

The bidder/contractor shall provide type test report/s & certificate/s of the FO cable from NTDC's approved laboratory/agency proving that the proposed FO Cable complies with IEC standards.

The bidder/contractor shall provide duly filled technical data sheets (comparison of data) of the offered & required FO cable in the bidding document along with its supporting constructional details, diagrams, sketches & original technical documents/brochures.

(f) Ending rules

After factory acceptance, the inner end of the cable shall be fitted with an end cap to ensure water-tightness; the outer end shall be fitted with a watertight head compatible with cable pulling. Caps (material and implementation) shall comply with applicable standards. They shall not be removed until start of FO cable drum test and splicing /jointing of fibers in the OJBs /OTB /ODF.

(g) Cable Drums

Fiber optic cables shall be delivered on drums of wooden reels. The lengths of the FO cable drums shall be such that intermediate jointing is kept to a minimum on any of the fiber optic cable routes. The drums should contain agreed lengths of FO cable as per approved laying schedule and minimum length of the FO cable on a drum shall not be less than 5000m generally. The barrel diameter of the shipping drums shall be large enough at

least 30 times the outer diameter of the cable, but not less than 400 mm to prevent damage to the FO cable during reeling/unreeling.

Wooden lagging or other suitable means of protection shall be applied to the drum to prevent damage to the FO cable during shipment & storage. The drums/reels will be non-returnable. The FO cable ends shall be sealed using shrinking caps and fasten tightly. A protective wrap shall be applied over the outer layer of the FO cable on each reel. The protective wrap must be weather resistant which should not be removed until cable installation. For test purpose, an extra length of at least 4 meter of inner FO cable end shall be accessible without removing wooden lagging. This length shall be securely fastened and protected during shipment and handling.

All of FO cable drums shall be open and accessible during the FAT of the FO Cables (whole lot).

Fiber optic cable drums/reels shall be fitted with securely attached, unalterable identification plate of approved format bearing the following information:

- Supplier's name: _____
- Manufacturer's name: _____
- Contract number: _____
- Project name: _____
- Content (including drum no.): _____
- Fiber optic cable type: _____
- Measured Attenuation coefficient of FOC: _____
- Sr.No. & Drum No.: _____
- Length of FOC on the drum: _____
- FOC manufacturing date: _____
- Arrow indicating rolling direction: _____
- Position of the FO cable nose: _____
- Weight of FO cable drum: _____

(h) Marking and Labelling

The outer sheath of the fiber optic cable shall have the following permanent marking, repeated every 1.00 m:

- Fiber Optic Cable: _____
- FO Cable Type No.: _____
- Manufacturer's Name: _____
- Year of manufacturing: _____
- Length of cable (running meter): _____

Moreover, proper labels of approved format & material shall be provided in on regular intervals and on both ends of all FO cables & on all approach FO cables. Proper labels of approved format & material shall also be provided on the PVC ducts/flexible pipes (through which FO cable or approach FO cable is laid) on regular intervals on the whole FO Cable route inside & outside (if applicable) the substation. The labels to be fixed on

the FO cable and PVC ducts/flexible pipes of FO cable shall show the following information:

- Fiber Optic Cable & Type: _____
- FOC End-A (OJB): _____
- FOC End-B (ODF/OTB): _____
- Remote Station: _____
- Project: _____
- Installation Date: _____

(i) Storage and Transport

The permissible mechanical stress values (tensile force, bending radius) shall be adhered to during transport and storage.

The transportation and storage shall not be done in conditions exceeding the permissible temperature limits.

4.2 Underground Fiber Optic Cable Installation

FO cable laying, in general, includes directly buried, in trenches, in tunnels, in ducts, on cable trays / ladders and in rooms, fastening on racks, cable brackets or supporting structures and joint supports, jointing of fibers in transit OJBs on the FOC route, entry & fixing of FOC in the OTB / ODF panel. This also includes termination of all fibers of the FOC in the OTB / ODF Rack (Fiber Optic Patch Panel) at both ends, splice loss measurement and end-to-end test of all fibers.

The fiber optic cable shall be laid in a buried 100mm PVC duct from / to the optical joint boxes (OJBs) where trench does not exist. However, in the substation premises /switchyard area, it shall be laid from terminal OPGW /FOC Joint Box (OJB) located at overhead line gantry up to control / telecom building in flexible PVC pipe running on cable trays through trenches. Within substation building, it shall be laid in a flexible duct/pipe on cable trays / ladders up to ODF Cabinet or Optical Termination Box (OTB) in Telecom Room. However, on the portion from the terminal OPGW /FOC joint box located at overhead line gantry up to the nearest connecting concrete trench, the approach fiber optic cable shall be laid through GI pipe.

Extra length (about ten meters) of the approach FO cable shall be kept at both ends. The extra length of the approach FO cable on the outdoor OPGW / FOC Joint Box (OJB) side shall be properly coiled & dressed in circular loops keeping in view the minimum bending radius constraint and properly clamped inside the OHL gantry as per approved design.

The extra length of the approach FO cable on ODF Panel / OTB side in the telecom room shall be properly coiled & dressed in circular loops keeping in view the minimum bending radius constraint and kept below the raised floor or on the cable tray / trench below the ODF Cabinet / OTB.

Proper marking and labelling of approved format & material shall be provided on regular intervals and on both ends of the FO cables. Moreover, proper labels of approved format

& material shall also be provided on the PVC ducts / pipes (through which approach FO cable is laid) on regular intervals on whole FO Cable route.

Drawings showing the fiber optic cable & duct routing layout, installation details, optic cable link configuration and method statement for laying & testing of fiber optic cable shall be submitted to the NTDC-Telecom for approval prior to start laying of the FO cable.

In case the fiber optic cable is damaged during installation, the contractor is responsible to replace with new / healthy FO cable to the satisfaction of the NTDC-Telecom.

In case of underground fiber optic cable link between two sites, a trench 0.5 m wide x 1m deep shall be excavated for buried PVC duct with provision of manholes at every 1km distance for cable pulling and future maintenance. PVC duct shall be laid on a sand bed of at least 100mm thickness and shall be covered by sand layer of 300mm thick inside the excavated trench.

A cable warning tape shall be placed on the top of sand layer. It shall be bright yellow in color and of plastic material 300 mm wide by 0.1mm thick shall be supplied. The tape shall be continuously and indelibly marked in English and Urdu in black letters on yellow with the following words:

"CAUTION CAUTION CAUTION"

"FIBRE OPTIC CABLE 700 mm BELOW"

The excavated material shall be used for the remaining back filling of the trench. The openings to the ducts shall be closed with a suitable compound after the cable has been laid. At least 10 m loop of the fiber optic cable shall be kept in each manhole.

5. OPTICAL FIBER JOINT BOX (OJB) FOR FOCS JOINTS, OPTICAL FIBER TERMINATION BOX, OPTICAL FIBER DISTRIBUTION FRAME (ODF) RACK & CABINET

5.1 Optical Fiber Joint Box (OJB) for FO Cable-FO Cable Joints

Outdoor Joint boxes, for connection / interconnection of two / three / four sections of different FO cables at transit points on the FO cable route, shall be provided to protect the splices and shall be suitable for underground installation in harsh environment. The units shall be weatherproof type of protection Class IP65 made of non-corrosive aluminium alloy or similar material. The cover shall be provided with a long life neoprene gasket to provide a seal against moisture and dust. All of installation hardware, gland plates & glands, all fittings to secure & seal the FO cables in the gland plates, cable holders, cleats to secure the FO cables fitted inside the joint box, splicing sleeves, heat shrinking protective tubes, splice holders, organizers / fittings and internal splice cassettes & optical fiber splice kits to accommodate the required number of optical fiber splices (at least 48) for permanent optical fiber joint of FO cables shall be included. All jointing materials / accessories shall be sufficient for at least 1.2 times the number of required splices / fibers. The splice loss shall not be more than 0.05 dB. A spare stripped off length (approx. 1.5m)

of fibers of the FO cables shall be left inside the OJBs to repeat / remake faulty splices. Entry for four FO cables shall be available and cable inlets shall be properly sealed.

Operating temperature range shall be -20 to +80°C and relative humidity range 5-95%.

Each outdoor optical fiber joint box (FOC-FOC) shall be capable of hermetically sealed after jointing and hermetically resealed after reopening and reclosing. The joint boxes / enclosures shall be securely fixed inside FO cable joint manhole at transit locations (when the FO cable is laid underground) as per approved location layout drawings of the entire FO Cable link.

The contractor shall submit details engineering design drawings with related technical detail and concerned documents for the optical fiber optical fiber joints (OJBs) along with OPGW / FOC links design for approval to NTDC-Telecom / Engineer.

The bidder/contractor shall provide duly filled technical data sheets (comparison of data) of the offered & required OJB (for FOC-FOC jointing) in the bidding document along with its supporting constructional details, diagrams, sketches & original technical documents/brochures.

Name plates of approved format (in English language) giving important information shall be fixed to each optical fiber joint box (OJB) which shall have embossed characters and shall be made of weather proof material. The nameplate shall have the following information:

- Joint Box No. (Location No.): _____
- Type of Optical Fiber Joint Box (FOC-FOC): _____
- Owner: _____
- Consultant: _____
- Manufacturer name: _____
- Year of manufacture: _____
- No. of fibers: _____S.M
- Contract No.: _____
- Project: _____
- Substation Name: _____
- Direction (s): _____

In order to allow optical fiber joint box / joint enclosure to move out from the underground joint manhole for jointing / splicing purpose, suitable extra lengths of each FO Cable (about ten meters) shall be kept coiled inside the underground FOC joint manhole.

5.2 Optical Fiber Termination Box (OTB)

The optical fiber termination box (OTB) is installed inside the telecom room and used to splice/terminate all optical fibers of underground FO cable or approach FO cable (other end jointed with OPGW fibers in outdoor OJB at the OHL gantry structure) inside the substation.

The fibers are spliced / terminated in low loss detachable connectors of approved type through pigtails. Wall mounted Optical Fiber Termination Box (OTB) will generally be used in case only one OPGW / FOC comes to the site. However, as a specific case two incoming FO cables can be terminated in one OTB, if deemed necessary, subject to prior approval from NTDC-Telecom based upon the optical fiber links configuration approved design.

Optical fiber termination boxes (OTB) shall be wall mounted type, compact size preferably having dimensions around 500mm x 15mm x 500mm (WxDxH) and having housing made of suitably painted stainless steel with protection degree at least IP 52. The OTB shall be fitted with easy to open / close front cover to access inside for FOC splicing work and fiber optic patch cords interconnections etc. The OTB shall be equipped with at least 48 nos. of detachable optical fiber connectors.

Each of OTB shall be supplied with complete mounting accessories, glands for at least four FO cable entries as well as sufficient no. of glands (min. six) for outlets of fiber optic patch cords (FOPCs) & fiber optic patch cord cables (FOPCCs), all fittings to secure & seal the FO cables / FOPCC in the gland plates, cable holders, cleats, splicing trays (48 fibers), splicing sleeves / tubes, heat shrinking protective tubes, splice holders, organizers & fittings to manage extra lengths of pigtails & fiber tubes, fiber & pigtail numbering stickers / labels for 48 fibers and optical fiber splice kits to accommodate the required number of splices for permanent joint between pigtail & FOC fibers, pigtails & detachable fiber connectors including mating connectors or pigtail with female connectors (as approved during design stage) etc. The connectors shall be fixed inside the OTB on connector holder, which shall allow easy access to each of the connectors. There should be sufficient space between two detachable connectors to allow easy connection / disconnection of fiber optic patch cords to the connectors. Type of detachable fiber connecters to be provided in the OTB will be advised & approved by NTDC during the design stage.

The buffer tubes shall be affixed in special fiber splice trays and stripped with sufficient extra length. The fibers shall be stored on these trays and spliced to the departing fibers or to the pigtails terminated with connectors.

The fiber optic patch cords (FOPCs) & fiber optic patch cord cables (FOPCCs) of suitable lengths (5/10 meters or as approved by NTDC) shall be provided with suitable male connector (type as approved by NTDC) in order to form connections with fiber connectors inside the OTB.

All jointing / splicing materials / accessories shall be sufficient for at least 1.2 times the number of required splices / fibers. The splice loss shall not be more than 0.05 dB. Laying of approach fiber optic cable (FOC) through PVC pipes / ducts on cable trays from outdoor OJB at the gantry to OTB in telecom room, jointing of fibers of its one end with OPGW in OJB at gantry, splicing / termination of all fibers of its other end in OTB in telecom room and fixing & dressing of the FOC below wall mounted OTB to floor including end-to-end test of fibers as per approved optical fiber configuration drawings

shall be the integral part of supply of OTBs. Type of detachable fiber connectors (to be provided in the OTB) will be decided / approved by NTDC during design stage. Operating temperature range for indoor OTBs shall be 0°C to +60°C. The optical fiber termination boxes (OTBs) shall be located & installed as per location layout drawings approved by NTDC.

In order to allow optical fiber termination box (OTB) to move to floor for re-splicing / re-termination of fibers, suitable extra lengths of each FO Cable (6 to 7 meters) shall be kept coiled below the OJB on the cable tray / trench or below raised floor in telecom room.

The bidder/contractor shall provide duly filled technical data sheets (comparison of data) of the offered & required OTB in the bidding document along with its supporting constructional details, diagrams, sketches & original technical documents/brochures.

The contractor shall submit detail engineering design drawings with related technical detail and concerned documents for the optical fiber termination boxes (OTBs) along with FO cable splicing & termination design for approval.

Name plates of approved format (in English language) giving important information shall be attached / fixed to each optical fiber termination box (OTB) which shall have embossed characters and shall be made of weather proof material. The nameplate shall have the following information:

- Optical Fiber Termination Box: _____
- Contract No. : _____
- Project: _____
- Substation Name: _____
- FOC Direction: _____

Identification labels of approved material, format & text shall also be provided on each of underground FO Cable, approach FO cable and fiber optic patch cords / cables at the entry point of each of optical fiber termination box (OTB). Moreover, labels shall also be provided at both ends of each of fiber optic patch cords / cables between OTBs and optical terminal equipment (OLTE) or other OTBs / ODFs.

5.3 Optical Distribution Frame (ODF) Rack and ODF Cabinet/Cubicle

The Optical Distribution Frame (ODF) in general consists of a floor mounted, fixed frame, hinged doors (front & rear), dedicated cubicle equipped with 19-inch slide-type ODF racks (Fiber Optic Patch Panels) and associated fittings/accessories to splice/terminate all optical fibers of each of incoming underground FO cables (UGFOCs) or approach FO cables (AFOCs) to the respective ODF Racks (Fiber Optic Patch Panels) individually in Telecom room at a substation. The fibers are spliced / terminated in low loss detachable connectors of approved type through pigtails in the ODF Racks

Optical fiber distribution frame (ODF Cabinet) equipped with ODF Racks (Fiber Optic patch Panels), as required, shall be provided to facilitate the termination of optical fibers of incoming FO cables in telecom room for onward interfacing / interconnection to optical transmission equipment or other OTBs / ODFs. One 24/48-fiber ODF rack (Fiber Optic

Patch Panel) with accessories shall be provided for each incoming 24/36/48-fiber FO Cable / Approach FO cable in the ODF Cabinet in Telecom Room at a substation. At least one no. of additional 48-fiber ODF rack (Fiber Optic Patch Panel) with accessories shall also be provided in the same ODF cubicle as integral part of supply of the ODF.

The ODF cabinet/cubicle shall preferably be installed nearer to the optical transmission equipment panels keeping in view the available extra length of the existing approach FO Cable and front & rear access of the ODF Cabinet in the telecom room.

The Optical Distribution Frame Cabinet/Panel shall consist of fixed frame self-supporting/standing cabinet/cubicle (WxDxH:800x600x2100 mm), made of suitably painted stainless steel (minimum thickness 2mm) with at least IP52 protection index, RAL7031 colour, front hinged door of metallic frame fitted with transparent glass of sufficient mechanical strength and hinged metallic rear door (doors opening angle 120 degrees minimum) with handle locks & keys, separate latch(es) within the doors, vermin proof bottom plates & gland plates with required nos. & sizes of glands for bottom entry of all types of FO cables & FO patch cords/cables and fitted with 19 inch slide-type ODF Racks (Fiber Optic Patch Panels) & accessories/fittings. Air filters, cubicle light which turns on/off when cubicle doors opened/closed, 220VAC power supply socket with input & output terminals block, thermostat, heater & hygrometer, document pocket etc shall also be provided & fitted in the ODF cabinet/cubicle as per NTDC's approved design drawings. A minimum of 15 cm free space shall be kept above the top one ODF Rack (first ODF Rack) and 20 cm space shall be kept below the bottom ODF Rack (the last ODF Rack) in the ODF cubicle. The ODF cubicle/cabinet shall be installed/fixed on steel supporting base frames of approved design where either suitable place on the existing trenches is not available or proper trench(s) are not available in telecom/related room(s).

Each ODF rack (Fiber Optic Patch Panel) shall be slid/pull-out type 19 inch rack and shall be supplied & equipped with at least 48 nos. of low loss optical demountable connectors of plug-in type with caps on both sides on the front plate, pigtails, splicing trays for 48 fibers, splicing sleeves/tubes for 48 fibers, splice protection holders, organizers & fittings to manage extra lengths of pigtails & fiber tubes, fiber & pigtail numbering stickers / labels sufficient for all fibers, FO patch cords and FO cables entry points including glands with strain free clamps and associated material / hardware / accessories etc. required for splicing / termination of FO Cables of minimum 48-fibers in ODF rack (Fiber Optic Patch Panel) and patch cords connection to external equipment complete in all respects. The 24-fiber & 48-fiber ODF racks shall be of heights 1U type & 2U type respectively as required/applicable. Front plat of 1U type & 2U type ODF racks shall consist of 24-connectors 1-row & 2-rows respectively. There should be sufficient space between two detachable connectors (about 20mm) mounted on front panel of the ODF rack to allow easy connection/disconnection of fiber optic patch cords (FOPCs) to the fiber-connectors.

Type of fiber connecters to be provided on the front plate of the ODF racks (Fiber Optic Patch Panels) will be advised & approved by NTDC during the design stage.

All of jointing / splicing materials / accessories, to be supplied as integral part of supply of ODF Rack, shall be sufficient for at least 1.2 times the number of required splices / fibers. The splice loss shall not be more than 0.05 dB.

The fiber optic patch cords (FOPCs) & fiber optic patch cord cables (FOPCCs) of suitable lengths (3, 5, 10 meters or as required & approved by NTDC) shall be provided with suitable male connector (type as approved by NTDC) in order to carry out connections/interconnection between ODF Racks or between optical line terminal equipment and ODF Racks etc.

The ODF Racks shall be fitted on a fixed frame inside the ODF cubicle/cabinet. Fiber optic patch cords management plate (of 2U height) fitted with smaller rings/guides shall be provided under each of the ODF rack (Fiber Optic Patch Panel) for horizontal management of the FO patch cords connecting the ODF rack.

Management rings/guides shall be installed in vertical columns in front-left & front-right sides inside the ODF cubicle for guiding & neat management of FO patch cords from bottom to top leading to connection to the concerned ODF racks (Fiber Optic Patch Panels). Vertical metallic wire mesh cable trays / perforated metallic vertical cable trays shall be provided on the inner-left & inner-right walls of the ODF cubicle for binding/dressing/management of extra lengths of FO Patch cords/cables. Horizontal metallic bars shall be provided on rear side of the fixed frame inside the ODF cubicle for binding & dressing of the underground/approach FO cables entering the ODF cubicle and terminated in the respective ODF racks (Fiber Optic Patch Panels) inside the ODF cubicle.

Supply & implementation of FO patch cord cables (FOPCCs) and FO patch cords (FOPCs) with compatible connectors of suitable/approved lengths for connection between optical transmission / communication equipment and ODF Racks as well as for cross-connections among the ODF Racks or between new ODF racks and existing OTBs/ODF shall be supplied as an integral part of ODF supply. External FO patch cords, to be laid between ODF panel (Fiber Optic Patch Panel) and optical transmission / communication equipment panels, shall be of twin-core Patch Cord Cables (PVC sheathed). Normal FO patch cords can be used for interconnection/cross-connection of optical fibers among ODF Racks (Fiber Optic Patch Panels) inside the same ODF Cubicle.

Laying of approach fiber optic cables (FOCs) through PVC pipes/ducts on cable trays from outdoor OJB at the gantry to ODF cabinet in telecom room, jointing of fibers of its one end with OPGW in OJB at gantry, splicing / termination of all fibers of its other end in the respective ODF Racks in ODF Cabinet in telecom room and fixing & dressing of the FO Cables inside the ODF Cabinet/Cubicle including end-to-end test of fibers as per approved optical fiber configuration drawings shall be integral part of supply of ODF Racks/Cabinet.

Type of detachable fiber connectors (to be provided in the ODF racks) shall be decided / approved by NTDC during design stage. Operating temperature range for the ODFs shall be 0°C to +60°C. The ODF cabinet / cubicle shall be located & installed as per location layout drawings approved by NTDC.

In order to allow the ODF Rack to move to floor for re-splicing / re-termination of fibers, appropriate extra lengths of each Approach FO Cable (about 6 meter or as approved by NTDC-Telecom) shall be kept coiled below the ODF cubicle on the cable tray/trench or below raised the floor in telecom room.

The bidder/contractor shall provide duly filled technical data sheets (comparison of data) of the offered & required ODF-Rack (Optical Fiber Patch panel) as well as ODF Cabinet/Cubicle in the bidding document along with the related constructional details, diagrams, sketches & original technical documents/brochures.

The contractor shall submit details engineering design drawings with related technical detail and concerned documents for the optical fiber distribution frame (ODF Cabinet and ODF Racks) along with FO cable splicing & termination design for approval from NTDC.

Labels of approved material, format & detail shall be provided on the ODF cubicle, on each ODF rack, FO cables and FO patch cords/cables.

Name plates of approved format (in English language) giving important information shall be fixed on optical fiber distribution frame cabinet (ODF Cubicle) and on each of optical fiber distribution frame rack (ODF Rack) which shall have embossed characters and shall be made of weather proof material. The nameplate shall have the following information:

Optical Fiber Distribution Frame Cabinet (ODF)

- Contract No.: _____
- Project : _____
- Substation Name: _____

Optical Fiber Distribution Frame Rack (ODF Rack)

- Contract No. : _____
- Project : _____
- Substation Name: _____
- FOC Direction: _____

Identification labels of approved material, format & text shall also be provided on each of underground FO Cable, approach FO cable and fiber optic patch cords/cables at the entry point inside the ODF Cubicle and at entry point on backside of each of ODF rack. Moreover, labels shall also be provided at both ends of each of fiber optic patch cords / cables between ODFs and optical terminal equipment (OLTE) or other OTBs/ODFs.

6. OPGW TESTS

6.1 Factory Tests on OPGW

6.1.1 General

Tests for OPGW shall be mainly on functional basis and shall include Factory Acceptance Tests (FATs) and Site Acceptance Tests (SATs). All OPGWs, OJBs and associated hardware & fittings shall be tested in the manufacturer's works. The contractor shall be required to carry out some or all of the tests stated in this specification as required by NTDC-Telecom under witness of Employer / Engineer (NTDC-Telecom / Engineer). Any other test that is found necessary to be performed as required by Employer / Engineer, the

same shall be added to the Factory Acceptance Tests and / or Site Acceptance Tests Protocols.

Testing of the OPGW stated herein shall be performed in line with this specification and in accordance with the relevant Standards. Where no appropriate standard is available, test shall be available, subject to the approval of Employer/Engineer.

Acceptance by Employer / Engineer of any equipment shall not relieve the Contractor / Manufacturer from any of his contractual obligations.

Employer / Engineer reserves the right to perform the checks during manufacturing process at any time. It shall be at the discretion of the Employer / Engineer to witness test on 100 % or any percentage quantity of each lot for routine tests / Factory Acceptance Tests, apart from the type test, wherever called for. However, witnessing of commissioning & Factory Acceptance Tests (End-to-End tests) shall be performed on 100% complete installation of each lot.

6.1.2 Type Tests of OPGW:

Type Tests of the OPGW shall be performed in accordance with approved Type Tests Procedure. The same shall comprise of but not limited to, Mechanical Characteristics, Environmental Characteristics and Transmission & Optical Characteristics as per latest IEC and ITU-T standards.

OPGW shall successfully pass the following tests based on the requirements of IEEE 1138-2009, unless otherwise stated.

6.1.2.1 Optical Fiber Tests:

Mode Field Diameter Test:

Mode field diameter of fibers of the FO cable shall be measured in accordance with mode field diameter test described in ITU-T G652/IEC 60793-1.

Cladding Diameter Test:

Cladding diameter of fibers of the FO cable shall be measured in accordance with cladding diameter test described in ITU-T G652 / IEC 60793-1-A2.

Non-circularity Test:

Core non-circularity of fiber shall be measured in accordance with non-circularity test described in ITU-T G652 / IEC 60793-1-2-A2.

Mode Field concentricity Error Test:

Mode field concentricity Error of fiber shall be measured in accordance with mode field concentricity error test described in ITU-T G652 / IEC 60793-1-2-A2.

Chromatic Dispersion Test:

Mode field concentricity error of fiber shall be measured in accordance with chromatic dispersion test described in ITU-T G652 / IEC 60793-1-C5A.

Cut-off Wavelength:

In order to measure of cut-off wavelength the fibers, the FO cable shall be subjected to cut-off wavelength measurement test described in EIA 455-80 Method A. The cut-off wavelength shall not exceed 1398 nm on each fiber otherwise it shall constitute failure of the test.

Attenuation Coefficient Test:

In order to measure of attenuation coefficient of the fibers, the FO cable shall be subjected to attenuation coefficient measurement test described in IEC 60793-1-40. The attenuation coefficient shall not exceed 0.4dB/Km at 1310 nm & 0.25dB/Km at 1550 nm on each fiber otherwise it shall constitute failure of the test.

Fiber Macrobending Sensitivity Test:

In order to measure of increase in attenuation due to fiber macrobending, the fiber shall be subjected to Fiber Macrobending Sensitivity Test described in IEC 60793-1-47 standard. The increase in fiber attenuation shall not exceed 0.05 dB at 1550 nm 1398 nm otherwise it shall constitute failure of the test.

6.1.2.2 Mechanical and Environmental Tests:

OPGW Dimensions Measurement:

The OPGW shall be subjected to following measurements described in IEC 60811:

- OPGW overall diameter
- Central metallic tube(s) diameter
- Thickness of central metallic tube(s) wall
- Plastic buffer tubes diameter & wall thickness

The measured values shall be within specified limits (tolerance +/-0.1mm).

Short Circuit Test:

The OPGW shall be subjected to the short circuit test as described in IEEE 1138-2009. An increase in attenuation greater than 0.05dB/km at 1550 nm shall constitute a failure. Bridging or breaking of the strands shall also constitute a failure. The maximum temperature attained during short circuit testing shall not exceed 180°C.

Aeolian Vibration Test:

The cable shall be subjected to the Aeolian vibration test described in IEEE 1138-2009. An increase in attenuation greater than 0.2 dB/km at 1550 nm shall constitute failure.

Galloping Test:

The cable shall be subjected to galloping test described in IEEE 1138- 2009. An increase in attenuation greater than 1.0dB/km at 1550nm shall constitute failure.

Sheave wheel Test:

The cable shall be subjected to a sheave wheel test as described in IEEE 1138-2009. Any significant damage to the OPGW core or strands in excess of 0.50 mm shall constitute failure. An increase in attenuation greater than 1.0dB/km at 1550nm shall also constitute failure.

Crush Test:

The cable shall be subjected to a crush load of 1750N/cm without significant damage to the optical core. The cable shall be tested in accordance with IEEE 1138-2009. An increase in attenuation greater than 0.10dB/km at 1550nm shall constitute failure.

Impact Test:

The cable shall be subjected to an impact test as described in IEEE 1138-2009. An increase in attenuation greater than 0.10dB/km at 1550nm shall constitute failure.

Creep Test:

The cable shall be subjected to creep test as described in IEEE 1138-2009.

Stress-Strain Test:

A Stress-Strain test shall be conducted on the cable to determine the stress-strain characteristics and the final modulus of elasticity (MOE) of the OPGW cable. The test shall be conducted as described in IEEE 1138- 2009.

Strain Margin Test:

A strain margin test shall be conducted on the cable to determine the amount of strain that the cable can withstand without placing strain on the optical fiber. The test shall be conducted as described in IEEE 1138- 2009. Any significant fiber strain below 50% of the cable's rated breaking strength shall constitute failure. The strain margin shall be above 50% of the cable's rated breaking strength. The strain margin is defined as the point at which the fiber strains at the same rate as the cable.

Ultimate Tensile Strength Test:

The cable shall be subjected to ultimate tensile strength test as described in IEEE 1138-2009.

DC Resistance Test:

The cable shall be subjected to DC resistance test as described in IEEE 1138-2009.

Bend Test:

The cable shall be subjected to Bend test as described in IEEE 1138-2009.

Twist Test:

The cable shall be subjected to Twist test as described in IEEE 1138-2009.

Lightning Arc Test

A lightning arc test shall be conducted on the cable to determine the mechanical and optical performance of the OPGW cable to lightning conditions that represent field conditions.

The cable shall be subjected to Lightning Arc test as described in IEEE 1138-2009.

Water Ingress Test:

The cable shall be subjected to Water Ingress test as described in IEEE 1138-2009.

Seepage of Flooding Compound Test:

The cable shall be subjected to Seepage of flooding compound test as described in IEEE 1138-2009.

Salt Spray Corrosion Test:

The cable shall be subjected to Salt Spray Corrosion test as described in IEEE 1138-2009.

Temperature Cycling Test:

The optical cable maintain mechanical and optical integrity when expose to temperature extremes from -40°C to +85°C. The cable shall be subjected to a temperature cycling test as described in IEEE 1138-2009. An attenuation change greater than 0.2dB/km at 1310nm and 1550 nm shall constitute failure.

The bidder / contractor shall provide evidence that the OPGW and Hardware & Fittings for OPGW to be supplied under this specifications has passed successfully all the type tests in respect of the optical, electrical, environmental and mechanical performance. The contractor shall be responsible to perform additional tests, if deemed necessary and required by NTDC-Telecom. In this regard, the bidder / contractor shall submit certified copies of type test certificates and type test reports (covering the above telecom requirements) from NTDC-Telecom approved international laboratory listed below.

Type tests certificates & reports will be acceptable if they are fully complied with the relevant Standards and the type tests conducted at an NTDC-Telecom approved international laboratory listed below or type tests conducted at the manufacturer's laboratory and witnessed by the representatives from NTDC-Telecom approved international laboratory listed below.

Failure to provide the certificates or if the presented type test certificates & reports are not in accordance with the above requirements then the bidder / contractor shall be responsible to make necessary arrangements to carry out the type tests in the Manufacturer's premises or at NTDC approved international laboratories under witnessing of representative of NTDC-Telecom and representative of below listed laboratories. Two inspectors from Telecom NTDC shall witness the type tests and representative of below laboratories shall issue the relevant type test certificates and reports upon successful completion of the type tests. All the expenses regarding travel to / from country / city of the laboratories / manufacturer's premises, boarding, lodging, visa fees etc. for representative of Telecom-NTDC to witness the type test shall paid by the contractor. The contractor is responsible to perform type tests again in case of failure to provide the type test certificates & reports.

List of NTDC approved international laboratories are:

1) Kinectrics Lab, Canada
2) KEMA Lab, Holland
3) IREQ, Canada
4) CRIEPI, JAPAN
5) CESI, Italy
6) KERI Labs, Korea

6.1.3 Routine Tests on OPGW

The following tests shall at least be performed. The Contractor shall indicate the standards accordingly, which shall be internationally acceptable (i.e. IEEE, IEC, ASTM, DIN, BS...). In case OPGW is of special design, the Contractor shall attach tests report of similar design for reference. The tests to be performed are:

Tensile Test:

With indicated over length of fiber and simultaneously measured attenuation at 1310nm and 1550nm.

Bending Test:

Similar to DIN VDE 0472 Teil 232; the bending radius shall be 25xouter diameter of OPGW and the test shall be carried out successfully if the attenuation of the straightened fiber is within the fiber standards limits.

Water Penetration Test (Tube):

Similar to DIN VDE 0472 Teil 811 test shall be successful, if no water is visible at the end of the tube after a period of 24 hours.

- Attenuation test using OTDR.
- Chromatic Dispersion test.
- Geometry tests.

In addition, the Contractor shall carry out tests of the single wires according to one of the above mentioned standards. For parts of the OPGW that are greased, the Contractor shall attach data sheets of the grease.

6.2 Site Tests for OPGW

(a) General

Testing of the OPGW on site will be carried out as per following schedule. In case the failure of OPGW occurs due to any macro bend, irregularity or found any other defect during testing, then contractor shall be responsible to replace it with new OPGW. The Contractor shall depute a competent person certified by the OPGW manufacturer to carry out these tests. These tests will be witnessed by the NTDC-Telecom representatives / Engineer.

(b) Testing of OPGW on receipt at Site (Pre-Installation Drum Test):

The following pre-installation tests shall be carried out by the contractor for all fibers of each OPGW drum. Any defect found in the fiber(s) shall constitute failure of the whole OPGW cable drum.

- OTDR test
- Attenuation test

(c) Testing of OPGW after Installation (Post-Installation Drum Test):

The following post-installation tests shall be carried out by the contractor for all fibers of each OPGW drum length installed on OH Line before splicing / jointing the fibers of two OPGW sections. Any defect found in the fiber(s) shall constitute failure of the whole OPGW section (drum length) installed on OH Line. The contractor shall be responsible to replace such defective / faulty OPGW section with new OPGW of the same section length.

- OTDR test of each fiber for each of the individual section of OPGW laid before splicing of to join two sections.
- After splicing of optical fibers of two sections of the OPGW, splice loss measurement through OTDR of all of fibers at all of intermediate jointing locations (OJBs at intermediate OHL towers).

(d) Site Acceptance Test of OPGW (End-to-End Test):

The following tests shall be carried out by the contractor for all fibers of complete OPGW link (between OJB on the gantry at station-A (on one end of the OPGW) and OJB on the gantry at station-B (on other end of the OPGW) after completing the splicing work of the whole OPGW link between two stations. The contractor shall perform OTDR & optical power meter tests both from station-A to station-B and them from station-B to station-A at both ends of the OPGW Link. If any OPGW section & associated hardware and OJBs (at intermediate & terminal points) is found defective / faulty during the inspection & test of the complete OPGW link, the contractor shall be responsible to replace such defective items with new ones to deliver healthy OPGW link (complete in all respects) as per specification / standards and approved design.

Acceptance by NTDC's representative of any OPGW / hardware / OJBs and SAT of the OPGW Link shall not relieve the contractor & the manufacture from any of his performance guarantees, or from any of his other obligations resulting from the contract.

(i) Installation Inspection (Installation Validation) of complete OPGW Link:

Visual inspection for installation validation of complete OPGW link shall be carried out by NTDC-Telecom/Engineer in the presence of the authorized person from the contractor in accordance with OPGW Link Visual Inspection Procedure & Format approved by NTDC-Telecom. The visual inspection of OPGW link includes the following:

- Visual Inspection of OPGW Link (Tower to Tower).
- Visual Inspection of OJBs (at intermediate towers & at both ends on the gantry).
- Visual Inspection of fixing & dressing of loops/coils of extra length OPGW kept at intermediate towers & both ends on the gantry.

(ii) Site Acceptance Test (SAT) of complete OPGW Link:

Site Acceptance Test of complete OPGW link shall be performed in accordance with the above latest standards & specifications and as per OPGW Link SAT Procedure & Format approved by NTDC-Telecom which will be witnessed by NTDC-Telecom/Engineer. The test shall be performed by the contractor's representative,

certified by the manufacture of the OPGW / FOC as a competent person to test OPGW link, as per standards.

Site Acceptance Test (End-to-End Test) of all of fibers of complete OPGW link shall be carried out by the contractor between OJB at one end of OPGW link (OJB on the gantry at Station-A) and OJB at the other end of OPGW link (OJB on the gantry at station-B) consisting of the following tests:

- OTDR Test
- Attenuation measurement for all fibers
- Power Meter with Light Source Test
- Measurement of optical length of complete OPGW link & and distances OJBs from ends (continuity test).

The above mentioned tests shall be done both from Station-A to Station-B and from Station-B to Station-A.

Test of optical fibers of any OPGW/FOC link shall neither be acceptable prior to properly fixing/dressing of all of extra length loops of the OPGWs & FOCs with proper clamps in OHL towers/gantries at each of OJB location nor before doing Installation Validation Inspections of the OPGW links & associated OJBs satisfactorily.

Without successful SAT (end-to-end tests) of the complete OPGW links (complete in all respects), supply & installation of the OPGW/FOC link as a whole lot shall be treated as incomplete work.

6.3 Tests on OPGW Hardware & Fitting

(a) Type Tests

Type tests are intended to verify and establish design characteristics. The tests shall be made once only on hardware identical in all essential details with those to be supplied.

The type tests to be performed on the OPGW hardware fittings shall include at least the following:

- Mechanical test; on each item of hardware.
- Resistance to conductor slippage test; on suspension clamps and tension sets.
- Vertical fatigue test; the stock bridge damper shall be installed on a shaker at the recommended torque and vibrated at the highest resonance frequency with an amplitude of ±1mm. The test shall be continued for 10 million cycles. After the test, no breakage of any part shall occur and the torque on the bolt is not less than 60% of the recommended value of the torque.

(b) Routine Tests

Tests shall be made to verify the quality and workmanship. The routine tests to be performed shall be:

- On all items of hardware:
- Visual examination. Verification of dimensions.
- Mechanical tests.

- On suspension clamps and tension sets.

7. FIBER OPTIC CABLE TESTS

7.1 Factory Acceptance Tests (FAT) on Fiber Optic Cable

7.1.1 General

Tests for fiber optic cable (FOC) shall be mainly on functional basis and shall include Factory Acceptance Tests (FATs), Type Tests and Site Acceptance Tests (SATs). All FO Cables and associated OJBs, OTBs and ODF Racks & Cabinets shall be tested in the manufacturer's works. The contractor shall be required to carry out some of tests or all of the tests stated in this specification as required by NTDC-Telecom witnessed by Employer / Engineer (NTDC-Telecom / Engineer). Any other test that is found necessary to be performed as required by Employer / Engineer, the same should be added to the Factory Acceptance Tests and Site Acceptance Tests Protocols.

Testing of the FO Cable stated herein shall be performed in line with this specification and in accordance with the relevant Standards. Where no appropriate standard is available, test shall be performed, subject to the approval of Employer / Engineer.

Acceptance by Employer / Engineer of any equipment shall not relieve the Contractor / Manufacturer from any of his contractual obligations.

Employer / Engineer reserves the right to perform the checks during manufacturing process at any time. It shall be at the discretion of Employer / Engineer to witness the routine tests / factory acceptance tests apart from the type test on either 100% or any percentage quantity of each lot, wherever called for. However, witnessing of commissioning & factory acceptance tests (Inspection & End-to-End tests) shall be performed on 100% of each lot upon completion of FO cable links.

7.1.2 Type Tests of Fiber Optic Cable:

Type Tests of the FO cable shall be performed in accordance with approved Type Tests Procedure. The same shall comprise of but not limited to Mechanical, Environmental and Optical characteristics / performance as per latest IEC, TIA / EIA, ICEA and ITU-T standards.

7.1.2.1 Optical Fiber Tests:

Mode Field Diameter Test:

Mode field diameter of fibers of the FO cable shall be measured in accordance with mode field diameter test described in ITU-T G652/IEC 60793-1.

Cladding Diameter Test:

Cladding diameter of fibers of the FO cable shall be measured in accordance with cladding diameter test described in ITU-T G652 / IEC 60793-1-A2.

Non-circularity Test:

Core non-circularity of fiber shall be measured in accordance with non-circularity test described in ITU-T G652 / IEC 60793-1-2-A2.

Mode Field concentricity Error Test:

Mode field concentricity Error of fiber shall be measured in accordance with mode field concentricity error test described in ITU-T G652 / IEC 60793-1-2-A2.

Chromatic Dispersion Test:

Mode field concentricity error of fiber shall be measured in accordance with chromatic dispersion test described in ITU-T G652 / IEC 60793-1-C5A.

Cut-off Wavelength:

In order to measure cut-off wavelength of the fibers, the FO cable shall be subjected to cut-off wavelength measurement test described in EIA 455-80 Method A. The cut-off wavelength shall not exceed 1398 nm on each fiber otherwise it shall constitute failure of the test.

Attenuation Coefficient Test:

In order to measure of attenuation coefficient of the fibers, the FO cable shall be subjected to attenuation coefficient measurement test described in IEC 60793-1-40. The attenuation coefficient shall not exceed 0.4dB/Km at 1310 nm & 0.25dB/Km at 1550 nm on each fiber otherwise it shall constitute failure of the test.

Fiber Macrobending Sensitivity Test:

In order to measure of increase in attenuation due to fiber macrobending, the fiber shall be subjected to Fiber Macrobending Sensitivity Test described in IEC 60793-1-47 standard. The increase in fiber attenuation shall not exceed 0.05 dB at 1550 nm 1398 nm otherwise it shall constitute failure of the test.

7.1.2.2 Mechanical and Environmental Tests:

Cable Diameter Test:

The fiber optic cable shall be subjected to cable diameter test described in IEC 60811. The measured values shall be within specified limits (tolerance +/-0.05mm).

Sheath Thickness Test:

Sheath of the fiber optic cable shall be measured as described in IEC 60811. The measured values shall be within specified limits (tolerance +/-0.05mm).

Bend Test:

Ability of the FO cable to withstand cable bend, the cable shall be subjected to bend test described in IEC 60794-1-2 E11. The attenuation shall not increase 0.05 dB/fiber at 1550 nm. Increase in attenuation exceeding the specified value and/or any crack or damage of the cable sheath shall constitute failure.

Cable Cyclic Flexing Test:

In order to test the ability of the FO cable to withstand cable flexing, the cable shall be subjected to cable cyclic flexing test described in IEC 60794-1-2 E6. The attenuation shall not increase 0.05dB/fiber at 1550 nm. Increase in attenuation exceeding the specified value and/or any crack or damage of the cable sheath shall constitute failure.

Impact Test:

In order to test the ability of the FO cable to withstand impact, the cable shall be subjected to cable impact test described in IEC 60794-1-2 E4. The attenuation shall not increase 0.1 dB at 1550 nm on each fiber. Increase in attenuation exceeding the specified value and/or any crack or damage of the cable sheath shall constitute failure.

Crush Test:

In order to test the ability of the FO cable to withstand crush, the cable shall be subjected to cable crush test described in IEC 60794-1-2 E3. The attenuation shall not increase 0.1 dB at 1550 nm on each fiber. Increase in attenuation exceeding the specified value and/or any crack or damage of the cable sheath shall constitute failure.

Tensile Test:

In order to test the ability of the FO cable to withstand tensile loads, the cable shall be subjected to cable tensile test described in IEC 60794-1-2 E1. The attenuation shall not increase 0.1 dB/Km at 1550 nm on each fiber. Increase in attenuation exceeding the specified value and / or Fiber breakage and/or any crack or damage of the cable sheath shall constitute failure.

Temperature Cycling Test:

In order to test the ability of the FO cable to withstand temperature cycles, the cable shall be subjected to cable temperature cycling test described in IEC 60794-1-2 F1. The attenuation shall not increase 0.1dB/Km at 1550 nm on each fiber otherwise; it shall constitute failure of the test.

Torsion Test:

In order to test the ability of the FO cable to withstand torsion, the cable shall be subjected to cable torsion test described in IEC 60794-1-2 E7. The attenuation shall not increase 0.1 dB at 1550 nm on each fiber. Increase in attenuation exceeding the specified value and/or any crack or damage of the cable sheath shall constitute failure.

Flexing Test:

In order to test the ability of the FO cable to withstand repeated flexing in the service, the cable shall be subjected to cable flexing test described in IEC 60794-1-2 E8. The attenuation shall not increase 0.1 dB at 1550 nm on each fiber. Increase in attenuation exceeding the specified value and / or any crack or damage of the cable sheath shall constitute failure.

Abrasion Test:

In order to test the ability of the FO cable sheath to resist abrasion, the cable shall be subjected to cable abrasion test described in IEC 60794-1-2 E2. There shall not be any abrasion/perforation of the cable sheath otherwise; it shall constitute failure of the test.

The bidder / contractor shall provide evidence that the fiber optic to be supplied under this specifications has passed successfully all the type tests in respect of the optical, environmental and mechanical performance.

The contractor shall be responsible to perform additional tests, if deemed necessary and required by NTDC-Telecom.

In this regard, the bidder / contractor shall submit certified copies of the type test certificates and type test reports (covering the above telecom requirements) from NTDC-Telecom approved international laboratory listed below.

Type tests certificates & reports will be acceptable if they are fully complied with the relevant standards and the type tests conducted at an NTDC-Telecom approved international laboratory listed below or type tests conducted at the manufacturer's laboratory and witnessed by representatives from an NTDC-Telecom approved international laboratory listed below.

Failure to provide the certificates or if the presented type test certificates & reports are not in accordance with the above requirements then the bidder / contractor shall be responsible to make necessary arrangements to carry out the type tests in the Manufacturer's premises or at NTDC approved international laboratories under witnessing of representative of NTDC-Telecom and representative of below listed laboratories. Two inspectors from Telecom NTDC shall witness the type tests and representative of below laboratories shall issue the relevant type test certificates and reports upon successful completion of the type tests. All the expenses regarding travel to / from country / city of the laboratories/manufacturer's premises, boarding, lodging, visa fees etc. for representative of Telecom-NTDC to witness the type test shall paid by the contractor. The contractor is responsible to perform type tests again in case of failure to provide the type test certificates & reports.

List of NTDC approved international laboratories are:

1) Kinectrics Lab, Canada
2) KEMA Lab, Holland
3) IREQ, Canada
4) CRIEPI, JAPAN
5) CESI, Italy
6) KERI Labs, Korea

7.2 Site Tests for Fiber Optic Cable

(a) General

Testing of the fiber optic cable shall carried out at site as per schedule mentioned below. In case the failure of any section of underground/approach FO cable occurs due to any macro bend, irregularity or any other defect found during installation inspection & testing, then contractor shall be responsible to replace it with new FO cable. The Contractor shall depute a competent person certified by the fiber optic cable manufacturer to carry out these tests. These tests will be witnessed by the NTDC-Telecom representatives / Engineer.

(b) Testing of Fiber Optic Cable on receipt at Site (Pre-Installation Drum Test):

The following pre-installation tests shall be carried out by the contractor for all fibers of each of fiber optic cable drum. Any defect found in the fiber(s) shall constitute failure of the whole fiber optic cable drum.

- OTDR test
- Attenuation test

(c) Testing of Fiber Optic Cable after Installation (Post-Installation Drum Test):

The following post-installation tests shall be carried out by the contractor for all fibers of each fiber optic cable drum length laid underground though ducts / trenches / cable trays before splicing / jointing the fibers of two FO cable sections or before splicing / jointing the fibers of OPGW and underground / approach FO cable in the OJBs. Any defect found in the fiber(s) shall constitute failure of the whole OPGW/FO cable drum length laid. The contractor shall be responsible to replace such defective / faulty OPGW/fiber optic cable section with new OPGW/fiber optic cable of the same section length.

- OTDR test of each fiber for each of the individual section of fiber optic cable laid before splicing/jointing to other FO cable section or to OPGW.
- After splicing/jointing of optical fibers between two fiber optic cable sections and/or between approach FO cable and OPGW, splice loss measurement through OTDR of all of fibers at all of jointing locations (OJBs at intermediate joints, FOC-OPGW joint).

7.3 Site Acceptance Test (End-to-End Test) of Fiber Optic Cable / OPGW Link

The following tests shall be carried out by the contractor on all fibers of the complete FOC/OPGW link (Approach FO Cable-OPGW-Approach FO Cable or Underground FO Cable-OPGW-Underground FO Cable or Underground FO Cable-OPGW-Approach FO Cable) between ODF/OTB in Telecom Room at station-A at one end and ODF/OTB in Telecom Room at station-B at other end of the optical fiber link after completing the splicing / jointing work in the concerned OJBs on the whole Fiber Optic Link between the two stations.

If any underground/approach fiber optic cable section, OPGW section, OJBs and associated accessories (at intermediate & terminal points) on the whole FOC-OPGW-FOC link between the two stations are found defective during the Installation Validation Inspection or End-to-End Test of the complete fiber optic link, the contractor shall be responsible to replace such defective section(s) with new underground/approach FOC and/or new OPGW to deliver healthy & fully functional FOC / OPGW link (complete in all respects) as per specifications / standards and approved design.

Acceptance by NTDC's representative of any underground/approach FOC/OPGW/ hardware/OJBs/OTB/ODF and SAT of the FOC/OPGW Link shall not relieve the contractor & the manufacture from any of his performance guarantees, or from any of his other obligations resulting from the contract.

(i) <u>Installation Validation Inspection of complete OPGW/Fiber Optic Cable Link</u>:

Visual inspection for installation validation of complete FO Cable link or FO Cable-OPGW-FO Cable link shall be carried out by NTDC-Telecom/Engineer in the presence of the authorized person from the contractor in accordance with FOC Link Visual Inspection Procedure & Format approved by NTDC-Telecom. The visual inspection of OPGW link includes the following:

- Visual Inspection of FO Cable Link and intermediate OJBs.
- Visual Inspection of Approach FO Cable Link between OJB (FOC-OPGW Joint) at the gantry and OTB/ODF in Telecom Room at both ends of the FOC-OPGW-FOC link.
- Visual Inspection of OJB (FOC-OPGW Joint) at the gantry.
- Visual Inspection of fixing & dressing of loops / coils of extra length Approach FO Cable kept on the gantry at both ends.
- Visual Inspection of the optical fiber termination box (OTB) in telecom room at both end stations.
- Visual Inspection of the optical fiber distribution Frame (ODF) Rack & Cabinet in telecom room at both end stations.

(ii) Site Acceptance Test (SAT) of complete Fiber Optic Cable - OPGW Link:

Site Acceptance Test of complete FO Cable - OPGW link shall be performed in accordance with the above mentioned latest standards & specifications and as per FO Cable/OPGW Link SAT Procedure & Report Format approved by NTDC-Telecom, which will be witnessed by NTDC-Telecom / Engineer. The test shall be performed by the contractor's person who is certified by the manufacture of the FOC/OPGW as a competent person to test FOC/OPGW link as per standards.

Without successful SAT (end-to-end tests) of the complete FO Cable Link or complete FOC-OPGW-FOC Link between ODF/OTB in Telecom Room at Station-A and ODF/OTB in Telecom Room at Station-B (complete in all respects), supply, installation & implementation of the FO Cable/OPGW link as a lot shall be treated as incomplete work.

Site Acceptance Test (End-to-End Test) of all of fibers of complete FO Cable link or complete optical fiber link (Approach FO Cable-OPGW-Approach FO Cable Link) shall be carried out by the contractor from ODF/OTB in Telecom Room at station-A at one end and ODF / OTB in Telecom Room at station-B at other end of the optical fiber link consisting of the following tests:

- OTDR Test (splice loss and attenuation measurement)
- Attenuation loss measurement for all fibers.
- Power Meter with Light Source Test
- Measurement of optical length of complete optical fiber link.

The above mentioned tests shall be done both from Station-A to Station-B and from Station-B to Station-A.

If both installation of OPGW link and laying of approach FO cables from OJB at gantry to telecom rooms at both ends including splicing & termination of fibers in OTB / ODF is

carried out by a single contractor, the same contractor shall be responsible to perform splice loss measurement and End-to-End Test/SAT of complete optical fiber link (Approach FO Cable-OPGW-Approach FO Cable) between ODF in Telecom Room at Station-A and ODF in Telecom Room at Station-B as per NTDC-Telecom approved FOC / OPGW SAT Procedure and Format.

The underground power cable/OHL contractor, who lays the external underground fiber optic cable (UGFOC) up to ODF Cabinet in Telecom Rooms at one or both ends including splicing/termination of all fibers of the UGFOC in the concerned ODF-Rack(s) in the ODF Cabinets in telecom rooms, shall be responsible to perform splice loss measurement and End-to-End Test/SAT of complete optical fiber link (Underground FO Cable-OPGW- Underground FO Cable as applicable) between ODF in Telecom Room at Station-A and ODF in Telecom Room at Station-B as per NTDC-Telecom approved FOC The substation contractor or FO cable contractor, who lays approach FO cables from OJB at the gantry to ODFs in telecom rooms at both ends of the OPGW link including jointing of OPGW with approach FO cable in OJBs at the gantry & splicing / termination of FOC fibers in OTBs / ODFs in telecom rooms, shall be responsible to perform splice loss measurement and final SAT of complete optical fiber link (Approach FO Cable-OPGW-Approach FO Cable) from OTB/ODF in telecom room at station-A to OTB/ODF in telecom room at Station-B and vice versa as per NTDC-Telecom approved FOC/OPGW SAT Procedure and Format even if the OPGW link between station-A and station-B is installed by other contractor.

Before splicing / jointing of Approach FO cable with OPGW in OJBs at the gantry at both ends, the substation / FO Cable contractor shall get SAT Report (End-to-End Test) of the OPGW link (between OJB on OHL Gantry at Station-A and OJB on OHL Gantry at Station-B) along with concerned drawings from the OPGW contractor for reference.

Submission of satisfactory Splice Loss Measurement and consolidated final End-to-End Test/SAT Report of complete optical fiber link (Approach FO Cable-OPGW-Approach FO Cable or Underground FO Cable-OPGW-Underground FO Cable or Underground FO Cable-OPGW-Approach FO Cable) duly signed by the contractor & NTDC-Telecom / Engineer in consolidated form as per format approved by NTDC-Telecom / Engineer shall be responsibility of the contractor who provides, lays & terminated underground/approach FO cable in OTB/ODF in telecom room at the concerned stations which will be mandatory to accept the optical fiber link as fully commissioned link.

8. TEST EQUIPMENT, INSTALLATION AND MAINTENANCE TOOLS

The bidder shall provide details of all the test equipment, instruments, installation & maintenance tools of approved manufacturers, to be suppled consisting (as a minimum) of the following:

(i) Optical Time Domain Reflect meter (OTDR) of latest technology & version and preferably having dynamic range greater than 45dB (coverage range of at least 400 km) and OTS modules (1310 / 1550nm), coloured screen, software and all accessories including AC cord / adapter, rechargeable batteries, battery charger,

OTDR Launch Dummy Fiber Cable Box with connectors & adapters, proper carrying case etc.

(ii) One (01) set of test kit complete for tests of optical fibers and optical signal measurement consisting of Optical Power Meter, Optical Laser Source, Variable Optical Attenuator (in proper carrying case) with associated cables, connectors, fiber-attenuators, fiber-connector adapters (as required) & accessories including practical demonstration of each test equipment. Each of test equipment shall of latest technology, version and maximum available measurement range.

(iii) Fiber Optic Splicing Unit type Sumitomo FSM-50 or equivalent with alignment tools (fiber cleaver etc.) and all accessories including spare electrodes, AC cord / adapter, rechargeable batteries, battery charger, splice tray holder, work lamp, proper carrying case etc.

(iv) Fiber Optic Tool kits including:

- Stripper for 0.9 mm tight secondary coated and for 250 µm primary coated fibers - 1 no.
- Stripper for buffer tubes and cord-type fiber optic cables - 1 no.
- Cutting tool/s for the core of OPGW - 1 no.
- Fiber holder for stripping optical fibers - 1 no.
- High-precision cleaving tool - 1 no.
- Cleaning tissues, 200pcs/pack 1 pack.
- Cotton sticks for cleaning the V-grooves of a fusion splicer, 100pcs/pack 1 pack.
- Acetone, 300ml/bottle - 2 no.
- Moistener bottle for acetone - 2 no.
- Air blast, Dust-off - 1 no.
- Tweezers for handling optical - 1 no.
- Microscope 30X with universal connector adapter - 1 no.
- Cleaning cassette for fiber optic connectors - 1 no.
- Self-adhesive warning label "FIBRE OPTIC CABLE" Size 185mm x 15mm, 120 pcs/pack 1 pack.
- Number tape set with replacement rolls of numbers 0-9 1 set.
- Rugged carrying case - 1 no.

(v) User Instruction Manual and Technical / Specification Manuals of all tools and test equipment (in English language).

(vi) Additional recommended tools shall be listed and described separately.