

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LIMITED

TECHNICAL SPECIFICATION

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RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LIMITED

SUB-SECTION-I
(PART OF VOLUME-II)

GENERAL TECHNICAL REQUIREMENTS

SUB-SECTION-I

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**400kV D/C Transmission Line at 400kV GSS
PACHPADRA/BN9019002102**

SUB-SECTION-I

TECHNICAL SPECIFICATIONS

1. General Information and Scope

1.1 Scope

1.1.1 The following 400 kV D/C transmission line is included in the scope of the Contractor:-

LILO OF ONE CKT. OF EXISTING 400KV D/C RAJWEST – KANKANI LINE AT PROPOSED 400KV GSS PACHPADRA (TWIN MOOSE) - (35KMS) ON TURNKEY BASIS (DEPOSIT WORK)	Route length 35 kms.(Approx.)
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1.1.2 This Specification covers the following scope of works:

- (i) Detailed Survey, including route alignment, profiling, tower optimization & spotting soil resistivity measurement & geotechnical investigation and check survey,
- (ii) Fabrication, Proto inspection, Galvanizing and inspection & testing, supply of 400 kV double circuit transmission line towers and their required body extensions as per employer design including bolts, nuts and washers, anti theft type bolts & nuts, hangers, D-shackles, U-Bolts, bird guards and bird flappers (if required) of appropriate design if identified during the ESAI study (if conducted) or mentioned in Approvals to be received from Forest Department for given line sections as a necessary accessories anti-climbing devices, flat washers etc. and also all types of tower accessories like phase plates, number plates, danger plates, circuit plates, anti-climbing devices for all types of towers & their body extensions, design & supply of extensions (if not available with employer) and special tower. The scope also covers supply of other line material like insulator, hardware, accessories, Conductor , OPGW etc. (as per the bidding schedules) and also survey, check survey, foundation, erection, testing and commissioning of 400kV transmission line.

The scope of bidder also includes manufacturing, engineering, inspection & Testing at manufacturer's works for supply of material at site i.e. Disc insulators/Long Rod Insulators, hardware fittings for conductor , ACSR Moose Conductor and other line accessories etc.

- (iii) Type testing of all line material as per requirement given in related chapters,
- (iv) supply of bolts & nuts, Disc/long road insulators, GSS Earth wire, 24 Fiber (DWSM) OPGW fibre optic cable, Joint box (24Fibre), Hardware set for 24Fibre OPGW Fibre Optic cabling including all cable fittings & accessories, Hardware fittings for conductor & Earth wire and other line accessories,
- (v) selection of foundations for different types of towers and casting of foundation for tower footings as per employer's design, design of foundation for extension of tower (if not available with employer) and special towers for different type of soil condition,
- (vi) erection of towers, tack welding of bolts and nuts including supply and application of zinc rich primer and enamel paint, tower earthing, fixing of insulator strings, stringing of conductor, earth wire and OPGW fiber optic cable along with all necessary line accessories,

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- (vii) design, manufacturing, testing, supply and erection of aviation items including painting for day & night visual aids,
 - (viii) Destraining of Earth wire: Dismantling of earth bonds, vibration dampers, declipping & fitting in rollers, detensioning and collecting the material & depositing the same in our store and stacking.
 - (ix) testing and commissioning of erected transmission line and
 - (x) other items not specified above but required to complete the work.
- 1.1.2.1
- (a) The various items of work are described very briefly in the appropriate Schedule of BPS. The various items of the BPS shall be read in conjunction with the corresponding sections in the Technical Specifications including amendments and, additions, if any. The Bidder's quoted rates shall be based on the description of activities in the BPS as well as other necessary operations required to complete the works detailed in these Technical Specifications.
 - (b) The Unit rates quoted shall include minor details which are obviously and fairly intended, and which may not have been included in these documents but are essential for the satisfactory completion of the various works.
 - (c) The unit rate quoted shall be inclusive of all plant equipment, men, material skilled and unskilled labour etc. essential for satisfactory completion of various works.
 - (d) All measurements for payment shall be in S.I. units, lengths shall be measured in meters corrected to two decimal places. Areas shall be computed in square meters & volume in cubic meters rounded off to two decimals.
- 1.1.3
- The Contractor shall take delivery of the employer supplied materials at the stores established by the contractor in consultation with the Employer and ensure their safe custody and shall incorporate the same in the transmission line as stipulated in this specification.
- 1.1.4
- All the raw materials, such as steel, zinc for galvanising, reinforcement steel, cement, coarse and fine aggregates for tower foundation, coke and salt for tower earthing etc. are included in the Contractor's scope of supply.
- 1.1.5
- Stringing**
- a) The entire stringing work of conductor and earth wire shall be carried out by tension stringing technique. The bidder shall indicate in their offer, the sets of tension stringing equipment he is having in his possession and the sets of stringing equipment he would deploy exclusively which under no circumstance shall be less than the number and capacity requirement indicated in Qualifying Requirements for Bidder. However, the Bidder having requisite experience has freedom to use helicopter for stringing. The Bidder intending to use helicopter shall furnish detailed description of the procedure, type & number of helicopter & accessories etc., to be deployed for stringing operation.
 - b) In hilly terrain and thick forest, where deployment of tension stringing machine is not possible, manual stringing may be adopted after getting approval of NIGAM site Engineer. The contractor shall deploy appropriate tools / equipments / machinery to ensure that the stringing operation is carried out without causing damage to conductor / earth wire and conductor / earth wire is installed at the prescribed sag-tension as per the approved stringing charts.

1.2 Details of Transmission Line Routes and Terrain

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The detailed survey shall be carried out using GPS, Total stations, digital theodolites etc. along the approved route alignment. As an alternative, the contractor may also use ALTM (Airborne Laser Terrain Modeling) techniques of equal or better accuracy for the detailed survey.

Bidders may visit the line route to acquaint themselves with terrain conditions and associated details of the proposed transmission lines.

1.3 Location Details and Terminal Points

1.3.1 The transmission line shall emanate in the state of Rajasthan for LILO of one ckt. of existing 400kV D/C Rajwest – Kankani line at proposed 400kV GSS PACHPADRA (Twin Moose) - (35kms) on Turnkey Basis

1.3.2 The Contractor shall have to construct the 400 kV transmission line completely up to dead end or terminal towers on either ends of the transmission line or part thereof. Stringing shall also be carried out from dead end tower to gantry/terminal arrangements/terminal points.

1.4 Access to the Line and Right of Way

Right of way and way leave clearance shall be arranged by the employer in accordance with work schedules.

2. Climatic and isoceraunic conditions

2.1 MAXIMUM TEMPERATURE

a)	Conductor (deg.C)	75
b)	Ground -wire (deg.C)	53

2.2 MINIMUM TEMPERATURE (DEG.C) (-) 2.5

2.3

i)	Max. ambient temp. (deg.C)	50
ii)	Mean annual temp. (deg.C)	32

2.4 RELATIVE HUMIDITY

i.	Maximum (percent)	90
ii.	Minimum (percent)	10
2.5	Average rainfall per annum (mm)	100-1000 mm
i.	Rainy months	May to August
ii.	Rainy days in a year	70
2.6	Average number of thunder storm days per annum	25
2.7	Height above mean sea level (m)	530 m
2.8	Basic Seismic co-efficient	
i.	Horizontal acceleration (g)	0.08
ii.	Vertical acceleration (g)	0.04
2.9	Terrain	Plain
3.0	SYSTEM PARTICULARS :-	
3.1	Line voltage (kV)	400
3.2	Highest system voltage (kV)	420
3.3	Number of circuits	2
3.4	Frequency (Hz.)	50
3.5	Neutral	Effectively earthed
3.6	Basic Insulation Level kV (peak)	1550
3.7	Power frequency withstand voltage (wet) kV (rms)	680
3.8	Switching surge withstand voltage (wet) kV (peak)	1050
3.9	Corona extinction voltage dry condition kV (rms)	320

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3.10 Radio interference voltage at one MHz for phase to earth voltage of 305 kV (rms) 1000 Micro volts

4.0 **PARTICULARS OF TOWERS FOR 400 KV TRANSMISSION LINES :-**

4.1 Normal Towers

a. Configuration

b. Normal span

c. Wind span

Vertical type

400 Metres

The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal ruling span.

d. Weight span:

Tower Type	Normal Condition		Broken wire Condition	
	MAX (m)	MIN (m)	MAX (m)	MIN (m)
DA	600	200	360	100
DB	600	0	360	(-) 200
DC	600	0	360	(-) 200
DD	600	0	360	(-) 300

e. No. of sub conductors per phase

Twin

f. Spacing between sub conductors

450 mm

g. Bundle arrangement

Horizontal

h. No. of ground wire

One+One OPGW

i. Shielding angle

20 deg.

j. Tower footing resistance

10 Ohms

k. Clearances

i) Minimum ground clearance from lowest point of power conductor + provision for ground undulation and sag error (mm) 8,840 + 150

ii) Minimum phase to phase clearance, based on the maximum permissible switching surge over voltage of 2.5 p.u between phase to ground (mm) 4000

iii) Minimum vertical mid-span clearance between power conductor and groundwire in still air (mm) 9000

iv) Swing angles and minimum clearance from live parts to tower body and cross arms.

• Suspension on insulator string in still air and when deflected up to 22 deg. (mm) 3050

• Suspension on insulator string when deflected due to wind up to 44 deg. (mm) 1860

• Jumper connection on tension towers in still air and wind up to 20 deg. from vertical (mm) 3050

• Jumper connection on tension towers when deflected by wind upto 40 deg. from vertical (mm) 1860

• Tension insulator strings on tension towers (mm) 3050

l. Minimum width of right of way

52 metres.

m. Minimum clearance for crossing over power lines

i) Above 400 kV (mm) 6100

ii) Above 220 kV (mm) 6100

iii) Above 132 kV (mm) & upto 33 kV 6100

n. Minimum clearance for crossing telecommunication lines (mm)

6100

o. Minimum clearance for Railway Track (mm)

a) Above rail track 19960

b) Above crane 6000

4.2 Configuration of 4 conductor per phase

a) for double circuit line

Vertical (I/ I/ I)

4.3 **FOUNDATIONS - particulars of :-**

1.	Properties of Soil	Ultimate bearing capacity (Kg/m sq.)	Angle of repose in degree
a.	Normal dry soil	27350	30
b.	Wet soil	13675	15
c.	Fissured rock/soft rock (both for dry as well as wet)	62500	20 in dry portion 10 in presence of water
d.	Hard rock	125000	-
e.	Ultimate bond between steel and concrete	15	-
2.	Weight of earth	Unit	Value
a.	Dry	Kg/M ³	1440
b.	Wet, partially sub merged & fully sub merged	Kg/M ³	940
c.	Fissured Rock	Kg/M ³	1440
4.4	Concrete mixture		

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a.	Slab		M-20 (1:1.5:3) with 20 mm broken stone
b.	Chimney		M-20 (1:1.5:3) with 20 mm broken stone
c.	Lean concrete sub base on pyramid		1:3:6 with 20 mm broken stone
4.5	Weight of concrete		
i.	Plain		Dry-2240 Kg/cum. Wet-1240 Kg/cum.
ii.	Reinforced		Dry-2400 Kg/cum. Wet-1400 Kg/cum.
4.6	GROUNDING OF TOWERS- particulars of :-		
i.	Maximum tower footing resistance	Ohms	10
ii.	Distance between the conductor of counter poise		30 m (approx.)

3.0 Qualification Requirement for Contractor's Supplied Line Materials

The Bidder should have assured access to supply Tower material, Disc Insulators, ACSR Moose Conductor, Hardware fittings and accessories for conductor and OPGW and other line materials from the manufacturers (Vendors) covered in the following list. However, the owner reserves the right to approve alternate vendors subject to meeting the technical specification, previous performances (with State/Central Transmission Utilities), availability of after sales support/service etc. in the overall interest of Nigam/Project.

In case, bidder is manufacturer of the items/equipments required for the project, then the bidder will supply own manufactured items/material. The vendors/manufacturers approved by the Nigam shall be final.

If the bidder proposes to supply material from vendors other than from approved vendors list then they shall furnish qualifying details of such vendors as detailed hereunder. Letter of Authorization/Undertaking from the Manufacturers as per proforma (Schedule-G) shall be submitted by successful bidder before commencement of supply.

S.No.	Equipment/Material	Minimum experience required
1	400KV Transmission Line Tower, Hardware Fittings and Accessories for Conductor, Disc Insulator, ACSR Moose Conductor, Danger/Phase/Number/Circuit plates, Pipe/Counter poise earthing, Galvanised Bolts & Nuts, Washers/Spring Washer/ Forged items (D-shackle, Hanger, U-Bolt), OPGW Cable & its H/W etc.	80% quantity of Equipment/Material covered in the Bid (equivalent or higher rating) should have been manufactured & supplied in any one year during the past five years by the manufacturer of that Equipment/Material covered in the Bid, as on the date of submission of request. Out of which 50% quantity of Equipment/Material covered in the Bid should have been satisfactory performance in any one year during the past five years. To substantiate above requirement the successful bidder shall furnish the following i. Certificate from Chartered Accountant bearing membership number with the name & address of the Chartered Accountant. The certificate should clearly indicate the quantity supplied, period of supply, name and address of the purchaser and end user. ii. Duly self-attested performance certificates from the purchaser/ end user clearly indicating the quantity supplied, date of commissioning, rating and voltage class.

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3.0 List of Approved Vendors

S. No.	NAME OF ITEM	NAME OF VENDORS
1.	Hardware Fittings and Accessories for Conductor and Earthwire	(i) M/s EMI Transmission Ltd., Mumbai (ii) M/s International Transmission Products Pvt. Ltd., Mumbai. (iii) M/s. IAC Electricals Pvt. Ltd., Kolkata (iv) M/s Asbesco India Pvt. Ltd., Kolkata (v) M/s Tyco Electronics (I) Pvt. Ltd., Bangalore (vi) M/s. TAG Corporation, Chennai (vii) M/s. Rashtraudyog Ltd., Kolkata (viii) M/s. Modern Malleables Ltd., Kolkata (ix) M/s Mosderfer Pvt. Ltd. Mumbai (x) M/s Rajasthan Transmat Pvt. Ltd., Jaipur. (xi) M/s Krsna Transmission Hardware Mfg. Pvt. Ltd., Vadodara (Gujarat).
2	Insulators: a) Porcelain Long Rod b) Disc c) Composite polymer Long Rod	(i) M/s. Modern Insulators, Abu Road (i) M/s. BHEL Amethi (UP) (ii) M/s. WSI, Chennai (iii) M/s. Aditya Birla Insulators, Hoogly (WB) (i) M/s Deccan Enterprises Pvt. Ltd. Hyderabad. (ii) M/S Olectra Greentech Limited, Hyderabad (M/s Goldstone Infratech Ltd, Secunderabad)
3.	Danger plate/Phase plate/Number plate/Circuit plate	(i) M/s Hind Enamel Works, Mumbai (ii) M/s J.K. Ceramicss, Pune (iii) M/s Lohar Engineers, Jaipur/Mumbai (iv) M/s. Premier Enamle, Aligarh (v) M/s. Kaveri Enamles and Allied Ltd., Bangalore
4.	Pipe type and Counter Poise earthing	(i) M/s Reliance Engineering Co., Thane (ii) M/s Lohar Engineers, Jaipur/Mumbai (iii) M/s. Aisha Transmission, Jaipur (iv) M/s. Supreme & Co. Pvt. Ltd., Kolkata (v) M/s. Larsen & Toubro, Pithampur/Pondicheri (vi) M/s. Madras Hard Tools Ltd., Chennai (vii) M/s Z.M. Engg. works, Mumbai (viii) M/s Modern Engineering Works, Mumbai (ix) M/s General Forging Works, Mumbai (x) M/s. Trans Accessories Forging Co., Mumbai (xi) M/s. Essar Forgings, Boiser (xii) M/s Reliance Fabricators, Jaipur (xiii) M/s. Aisha Transmission Products, Jaipur.

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5.	Galvanized Bolts & Nuts and Galvanized Step Bolt 16x175	<ul style="list-style-type: none"> (i) M/s. Nexo Industries Pvt. Ltd., Ludhiana (ii) M/s. A.V. Forgings, Mohali (iii) M/s. Ravi Engineers, Amritsar (iv) M/s. Karamtara Fasteners, Mumbai. (v) M/s. Deepak Fasteners, Ludhiana. (vi) M/s. Forex Fasteners, Ludhiana. (vii) M/s. Garg Fasteners, Ludhiana (viii) M/s Techman India, Chandigarh (ix) M/s A.S.P. Pvt.Ltd.,Howrah (x) M/s Millenium structures (India)Ltd., Indore (xi) M/s Sterling olts(P) Ltd., Howrah (xii) M/s G.K.W. Ltd., Howrah (xiii) M/s Pankaj International, Ludhiana (xiv) M/s Bharat Industries, Howrah (xv) M/s Precision Auto Engineers, Ludhiana (xvi) M/s J.C. Fasteners Limited, Rohtak (xvii) M/s DFL International Limited, Ludhiana (xviii) M/s Remax (India), Ludhiana (xix) M/s Bharati Overseas, Ludhiana (xx) M/s Anishika Fasteners Pvt. Ltd., Nagpur (xxi) M/s Precision Fasteners Limited, Mumbai (xxii) M/s HR Steel Industries, Howrah (xxiii) M/s Roshan Implex Pvt. Ltd., Ludhiana (xxiv) M/s Indian Steel and Wire Products Ltd. , Jamshedpur (xxv) M/s. Namdhari Industrial Traders Pvt. Ltd. Ludhiana
6.	Washers/ Spring Washers	<ul style="list-style-type: none"> (i) M/s. Nexo Industries Pvt. Ltd., Ludhiana (ii) M/s. Springlock Industries, Vadodara (iii) M/s. Chempromech Engineers, Nagpur (iv) M/s. Forbes & Gokak Ltd., Mumbai (v) M/s. Navin Metal Industries, Kolkata (vi) M/s. Forex Fasteners, Ludhiana. (vii) M/s. Ravi Engineers, Amritsar (viii) M/s Roshan Implex Pvt. Ltd., Ludhiana (ix) M/s Pankaj International, Ludhiana (x) M/s Millenium structures(India) Ltd., Indore (xi) M/s. Garg Fasteners, Sherpur, Ludhiana. (xii) M/s. Namdhari Industrial Traders Pvt. Ltd. Ludhiana
7.	Forged items (D shackles, Hangers, U-Bolts) & Foundation Bolts & Nuts	<ul style="list-style-type: none"> (i) M/s. EMI, Thane (ii) M/s. Z.M. Engg. works, Mumbai (iii) M/s. Modern Engineering Works, Mumbai (iv) M/s. General Forging Works, Mumbai. (v) M/s. Aisha Transmission, Jaipur (vi) M/s Trans Accessories Forging Co. Mumbai (vii) M/s Essar Forgings, Boiser (viii) M/s. Skipper Limited, Kolkata (WB) (ix) M/s Reliance Fabricators, Jaipur.
8.	400kV Transmission line tower	<ul style="list-style-type: none"> (i) M/s. Skipper Limited, Kolkata (WB) . (ii) M/s. Varsana Ispat Ltd., New Dehli (iii) M/s. Namdhari Industrial Traders (P) Ltd., Ludhiana. (iv) M/s MAN Structural Pvt., Ltd., Jaipur (v) M/s. VSP Enterprises Pvt. Ltd. Haryana. (vi) M/s TATA Projects Ltd., Nagpur. (vii) M/s Nandan steel and power Ltd., Raipur.
9.	GSS Earth Wire	<ul style="list-style-type: none"> (i) M/s. Himachal Wire Industries Pvt. Ltd., Damtal (Kangra). (ii) M/s BAJRANG WIRE PRODUCTS (India) Pvt. Ltd., Jaipur . (iii) M/s.Nirmal Wires Private Limited, KOLKATA (iv) M/s.Kritika Wires Private Limited, Kolkata. (v) M/s Geekay Wires Hyderabad (vi) M/s Bedmutha Industries Limite, Nasik
10.	ACSR Conductor	<ul style="list-style-type: none"> (i) M/s PREM CABLES (P) LTD., PIPALIA KALAN, PALI

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		(ii) M/s VENKATESWARA WIRES PVT. LTD., JAIPUR (iii) M/s NECCONPOWER & INFRA LIMITED, JAIPUR (iv) M/s LUMINO INDUSTRIES LTD., KOLKATA (v) M/s JSK Industries Pvt Ltd., Mumbai. (vi) M/s. Apar Industries Ltd., Vadodara. (vii) M/s. Hind Aluminium Industries Ltd. , Mumbai. (viii) M/s Gupta Power Infrastructure Ltd., Bhubaneswar. (ix) M/s Transrail Lighting Ltd., Silvassa.
11.	24 Fiber(DWSM)OPGW Fibre optic cable/ H/w set /Joint Box	(i) M/z ZTT Gurgaon (ii) M/s Sterlite Technologies Ltd. Silvassa
12.	Obstruction Light (1MED+2LOW Intensity)/ Span Marker	(i) M/s Aavids Technovators Pvt. Ltd. New Delhi (ii) M/s. Geolights Pvt. Ltd.New Delhi. (iii) M/s Insta Power Ltd., Gurugram(HR).

4.0 TYPE TEST

- 4.1 Each equipment / item offered for supply against this specification shall be of a design which is already type tested as per the latest relevant standards and the requirements specified in this specification.
- 4.2 In the event of Order, the Contractor shall furnish the latest type test certificates from a Govt. / a Govt. approved /a Govt. recognized / NABL accredited laboratory / ILAC i.e. International Laboratory Accreditation Co-operation (in case of foreign laboratories) or the certificate of type test conducted at manufacturer's works duly witnessed by representative of any Electricity Board / Nigam / Govt. agency / PGCIL / NTPC or the certificate of type test conducted in the manufacturer's own lab located in the foreign country duly witnessed by independent agency (wherever specified in Technical Specification for particular item) for all the type tests wherever prescribed in the relevant latest editions of Indian Standards / International Standards, for approval. The type test certificates should not be older than 07 (SEVEN) years as on the date of Technical bid opening for which the date of conducting of test shall be considered. However, no separate type test charges shall be paid to the bidder.
- 4.3 Type test reports as per Clause 4.2 above for equipments / items manufactured by any of the approved vendors need not be submitted along with the offer. The type test reports shall be submitted for approval to RVPN at the time of drawing approval of equipment / item. Any delay on account of furnishing type test reports for approval shall not be considered for extension in completion period of the project.
- 4.4 If the type tests are more than seven year old then the bidder has to arrange for type testing the equipment/item at no extra cost to RVPN.
- 4.5 Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to RVPN.
- 4.6 Notwithstanding anything stated above, the RVPN's decision regarding type tests will be final and binding on the bidder.

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SPECIFIC TECHNICAL REQUIREMENTS

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CHAPTER-1

SURVEY AND ALIGNMENT

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CHAPTER-1

SURVEY AND ALIGNMENT

1.1 DETAILED SURVEY

- 1.1.1 The detailed Survey, including route alignment, profiling, tower optimization & spotting and check survey shall be carried out by the contractor. The contractor shall submit proposal for route approval of the 400 kV D/C transmission line along with route alignment drawings for Employer's approval. The details of EHV power line crossings, railway crossings, river crossings, national highway crossing and identified forest areas shall be indicated in the route alignment drawings. The Contractor shall examine all aspects of 400 kV D/C transmission line routing and satisfy the employer that all such requirements are met before the proposal is submitted. Also special attention is to be given to maintain clearance from telecommunication lines, railway and road crossings, airport, defence installations, mining area, forest, industries discharging/ polluting wastage and other enroute features that may be encountered.

The Detailed Survey shall be carried by using GPS, Total Work stations, long range scanners & Digital theodolites of reasonable accuracies or alternatively using ALTM (Airborne Laser Terrain Modeling) techniques, inter-alia including :

- i. Digitalised profiling along the selected route along with plan details.
- ii. Computer aided tower spotting & optimization
- iii. Soil resistivity measurement along the route

Check survey including digitised contouring at undulated / hilly tower locations. Preparation of Survey reports including estimation of Bill of Quantities, identification and explanation of route constraints (like Forest, Animal/Bird sanctuary, reserve coal belt areas, oil pipe line/underground inflammable pipe lines etc.), infrastructure details available en-route etc.

- 1.1.2 The Contractor shall finalise and submit proposal for all obligatory points within two months from the date of commencement of work at site. These obligatory points shall include all the River crossings, Railway crossings, Power line crossings or any other important crossings encountered in the transmission line route.
- 1.1.3 The bidder should note that Employer will not furnish the topographical maps prepared by Survey of India but will make available any assistance that may be required in obtaining the topographical maps.
- 1.1.4 The detailed survey shall be made along the approved alignment.

1.1.5 ROUTE MARKING

The route of the transmission line shall be recorded using GPS of positional accuracy less than 3m.

The co-ordinates of all the angle points as well as other important crossings, landmarks etc. shall be recorded using GPS for easy relocating.

At the starting point and all angle/section points concrete block 200X200 mm square and height 300 mm, with a teak wood peg 50X50X150 mm size embedded in the top surface, shall be buried in the ground with top at 50 mm below ground level. The concrete blocks shall have RVPN marked on them. A nail shall be fixed on the top of wooden peg to mark the instrument center. Teak wood peg 50X50X150 mm size shall be driven at prominent position and at interval of not more than 750 M along the transmission line route. These shall be placed at protected places so that they are not removed or displaced by any body.

1.1.5.1 REQUIREMENT OF TRANSMISSION LINE ROUTING:

- i. The routing of the transmission line shall be most economical from the point of view of construction and maintenance. The contractor shall identify & examine alternative route alignments and suggest to the Employer the optimal route alignment.

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- ii. Routing/Re-routing of transmission line through protected/reserved forest area should be avoided. In case it is not possible to avoid the forests or areas having large trees completely, then keeping in view of the overall economy, the route should be aligned in such a way that cutting of trees are minimum.
- iii. The route should have minimum crossings of Major River, Railway lines, National/State highways, overhead EHV power line and communication lines. The crossing of power and communication lines shall be minimum.
- iv. The number of angle points shall be kept to minimum.
- v. The distance between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.
- vi. Marshy and low lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.
- vii. It would be preferable to utilize level ground for the alignment.
- viii. Alignment will be kept at a minimum distance of 300 m from power lines to avoid induction problems on the lower voltage lines.
- ix. Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them.
- x. Areas subjected to flooding such as nalah and areas requiring special foundations and those prone to flooding should be avoided.
- xi. Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.
- xii. All power lines alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.
- xiii. Angle points should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.
- xiv. The line routing should avoid large habitations, densely populated areas, Forest, Animal/Bird sanctuary, reserve coal belt areas/ mining area, oil pipe line/underground inflammable pipe lines etc. to the extent possible.
- xv. For examination of the alternatives & identification of the most appropriate route, besides making use of information/data/details available/extracted through Survey of India Topographical maps; the contractor shall also carryout reconnaissance /preliminary survey as may be required for verification & collection of additional information /data /details.
- xvi. The contractor shall submit his preliminary observations & suggestions along with various information/data /details collected, topographical map data marked with the alternative routes etc. The final evaluation of the alternative routes shall be conducted by the contractor in consultation with Employer's representatives and optimal route alignment shall be proposed by the contractor. Site visit and field verification shall be conducted by the contractor jointly with the Employer's representative for the proposed route alignment.
- xvii. Final route alignment drawing with latest topographical and other details/features including all rivers, railway lines, canals, roads etc. up to 8 kms on both sides of selected route alignment shall be submitted by the contractor for Employer's approval along with report containing other information/details as mentioned above.
- xviii. Changes in the route alignment, if any, during detail survey, shall be incorporated in the final route alignment drawings.

1.1.6 PROFILE PLOTTING AND TOWER SPOTTING

The complete profiling along the route shall be carried out using modern surveying equipments viz. total stations, GPS, digital theodolite, long range scanners etc. Reference levels at every

20 metres along the route are to be recorded. R/Ls and other undulations along the route as well as in the route plan and other enroute details viz. crossings, building & structures, trees & other infrastructure etc. shall also be recorded. Areas along the route, which in the view of the contractor, are not suitable for tower spotting, shall also be marked.

The complete profiling details shall be digitized and the data shall be prepared & stored in the format compatible to computer-aided tower spotting software.

A printed/plotted output of the digitized profiling shall be submitted by the contractor to Employer's site-in-charge for review before taking up computer-aided tower spotting.

Optimisation of tower locations shall be done by the contractor using computer-aided tower spotting software and shall furnish sample calculations and manual tower spotting drawings for some typical sections.

The sag-tension characteristics of the conductor, tower spotting data and Sag template curves shall be prepared by the contractor.

While preparing the route profile, the tentative tower locations requiring revetment work shall also be clearly mentioned in the profile.

1.2 PRELIMINARY LINE ALIGNMENT AND SOIL RESISTIVITY MEASUREMENT

1.2.1 During execution of the project if due to some unavoidable reasons, the route is required to be diverted; the contractor shall have to submit the preliminary line alignment for the diverted position to the employer for approval. The alignment shall be plotted on Survey of India maps to the scale of 1cm=0.5km(1:50000). All the topographical details including all Railway lines, P&T Lines, rivers, canals, forests, roads etc. up to 8kms. on either side of the route of transmission line shall be drawn to the scale. After getting approval for the diverted alignment, the original tracing of the route alignment drawing shall be handed over to the employer.

1.2.2 The soil resistivity along the route alignment shall be measured in dry weather by the contractor. It shall be measured by the four electrode method keeping inter- electrode spacing as 50m. The measurement shall be made at every 2 to 3kms. along the line route of the transmission line and at all angle/section locations. In case soil characteristic changes within 2 to 3 km., the values shall have to be measured at intermediate locations. For calculating soil resistivity formula $2\pi ar$ (where $a=50$ metres and r = megger reading in ohms) shall be adopted. The megger reading and soil characteristics shall also be indicated in the soil resistivity results.

1.2.3 All the expenditure on account of the above shall be deemed to be included in the bid price and no extra payment shall be made for the same.

1.3 TOWER LOCATION

1.3.1 SAG TEMPLATE

Based on data of conductor, earth wire and insulator the contractor shall prepare the sag template and tower spotting data and submit the same along with sag tension calculations for the approval of the Zonal CE (T&C) RVPN. Only approved sag templates shall be used for tower spotting on the profiles. Seven copies of the approved template, prepared on rigid transparent plastic sheet, shall be provided by the contractor to the employer for the purpose of checking tower spotting. The template shall be on the same scale as that of the profile.

1.3.2 TOWER SPOTTING

With the help of approved sag template and tower spotting data, tower locations shall be marked on the profiles. While locating the towers on the profile sheet, the following shall be borne in mind:

(a) SPAN

The number of consecutive spans between the section points shall not exceed 15 spans or 5 km. in plain terrain and 10 spans or 3 km. in hilly terrain. A section point shall comprise of tension point with "B" or "C" or "D" type towers, as applicable.

(b) EXTENSION

An individual span shall be as near to the normal design span as possible. In case an individual span becomes too short with normal supports on account of undulations in ground profile, one or both the supports of the span may be extended by inserting standard body/leg extension designed for the purpose according to technical specification .

(c) LOADING

There shall not be any upward force on suspension towers under normal working conditions and the suspension towers shall support at least the minimum weight span as provided in the designs. In case minimum weight span is not obtainable, it shall be examined if the same can be obtained by adding standard body extensions to the towers failing which tension towers shall be employed at such locations.

(d) ROAD CROSSING

At all important road crossings, the tower shall be fitted with tension insulator strings but the ground clearances at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, the ground clearance of the conductor from the road surface will not be less than specified. At all national highways, tension towers shall be used and the crossing span will not exceed 250 m in any case.

(e) RAILWAY CROSSINGS

All the railway crossings, (coming-enroute) the transmission line shall be identified by the Contractor. At the time of detailed survey, the railway crossings shall be finalised as per the regulation laid down by the Railway Authorities. The following are the important features of the prevailing regulations (revised in 1987)

- i) The crossings shall be supported on D type tower on either side.
- ii) The crossing shall normally be at right angle to the railway track.
- iii) The minimum distance of the crossing tower shall be at least equal to the height of the tower plus 6 meters away measured from the centre of the nearest railway track.
- iv) No crossing shall be located over a booster transformer, traction switching station, traction sub-station or a track cabin location in an electrified area.
- v) Minimum ground clearance above rail level of the lowest portion of any conductor under condition of maximum sag shall be maintained at 19.96 m for 400 kV transmission line.
- vi) The crossing span will not exceed to 300 meters.
- vii) The Railway block charges per Railway crossing upto a maximum period of 2 (two) hours shall be payable by the NIGAM but charges for the additional period (beyond two hours) required , if any, shall be payable by the contractor.

The approval for crossing railway track shall be obtained by the employer from the railway authority, however, 6 copies of the profile and plan, tower and foundation design and drawings, required for the approval from the railway authority shall be supplied by the contractor to the employer free of cost.

(f) RIVER CROSSING

In case of Major River Crossings, towers shall be of suspension type using double suspension strings and the anchor towers on either side of the main River Crossing shall be 'D' type tower. Alternately on the basis of economics and / or site/ execution constraints crossing of rivers using extended angle towers also shall be considered. Clearance required by navigation authority shall be provided. For non-navigable rivers, clearance shall be reckoned with respect to highest flood level (HFL).

(g) POWER LINE CROSSING

Where the line is to cross over another line of the same voltage or lower voltage, 'B', 'C' or 'D' type tower with suitable extensions shall be used. Provisions to prevent the possibility of its coming into contact with other overhead lines shall be made in accordance with the Indian Electricity Rules, 1956 as amended up-to-date. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground-wire of the line to be crossed (if this is possible, and permitted by the Employer of the line to be crossed).

Minimum clearance in metres between lines when crossing each other:

S.No.	Nominal System Voltage	110-132KV	220KV	400KV	765KV
1.	110-132KV	3.05	4.58	5.49	7.94
2.	220KV	4.58	4.58	5.49	7.94
3.	400KV	5.49	5.49	5.49	7.94
4.	765KV	7.94	7.94	7.94	7.94

For power line crossings of voltage level of 132 kV and above, angle towers shall be provided adjacent to B type tower on either side of the Power line crossing which can be used in temporary dead end condition with proper guying to facilitate stringing of the power line crossing sections separately on obtaining line shutdowns.

(h) TELECOMMUNICATION LINE CROSSING

The angle of crossing shall be as near to 90 Deg. as possible. However, deviation to the extent as 30 Deg. may be permitted under exceptionally difficult situations. When the angle of crossing has to be below 60 Deg. the matter will be referred to the authority incharge of the telecommunication system. On a request from the Contractor, the permission of the telecommunication authority will be obtained by the Employer. Also, in the crossing span, power line supports will be as near-to the telecommunication line as possible, so as to obtain increased vertical clearance between the wires.

(i) DETAILS ENROUTE

All topographical details, permanent features, such as trees, building etc. 50 m on both sides of alignment shall be detailed on the profile plan. A distance of atleast 26 mtr. from center line of the route shall be maintained from all buildings and other constructions.

(j) Necessary copies of tracings and prints of plan, profile etc. required for the approval of PTCC, Forest, Road Crossing and Aviation etc. shall also be supplied by the Contractor.

1.4 CLEARANCE FROM GROUND, BUILDINGS, TREES ETC.

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the Indian Electricity Rules, 1956 as amended upto date.

The Contractor may please note that Employer shall not pay any compensation for any loss or damage to the properties or for tree cutting due to Contractor's work.

1.4.1 To evaluate and tabulate the trees and bushes coming within 26 m on either side of the central line alignment, the trees will be numbered and marked with quality paint serially from angle point 1 (I) onwards and the corresponding number will be painted on the stem of trees at a height of 1 meter from ground level. The trees list should contain the following:

- Girth (circumference) measured at a height of 1 meter from ground level.
- Approximate height of the tree with an accuracy of +2 meters.
- Name of the type of the species/tree.

- d) The bushy and under growth encountered within the 52 m (26 m on either side for 400 kV line should also be evaluated with its type, height, girth and area in square meters, clearly indicating the growth in the tree/bush statement.
- 1.4.2 The Contractor shall also identify the forest/non forest areas involved duly authenticated by concerned authorities.
- a) A statement of forest areas with survey/compartment Nos.(all type of forest RF/PF/Acquired forest/Revenue forest/Private forest/Forest as per dictionary meaning of forest etc.)
 - b) A statement of non-forest areas with survey/compartment nos.
 - c) Tree cutting details(Girth wise & specie wise)
 - d) Marking of forest areas with category on topo sheets 1:2,50,000 showing complete line route, boundaries of various forest divisions and their areas involved.
 - e) Village forest maps of affected line and affected forest area and marking of the same.
 - f) Forest division map showing line and affected forest area.
- 1.4.3 The Contractor shall finalize the forest clearance proposal on the prescribed format duly completed in all respects for submission by the Employer to the Forest Department.
- 1.5 **PRELIMINARY SCHEDULE**
- The profile sheets, duly spotted, along with preliminary schedules indicating type of towers, type of foundations, wind span, weight span, angle of deviation, river or road crossing and other details shall be submitted for the approval of the employer. After approval, the Contractor shall submit six more sets of the approved reports along with one set of reproducible of final profile drawings to the RVPN for record purpose.
- 1.6 **CHECK SURVEY OF TOWER LOCATION**
- 1.6.1 The check survey shall be conducted to locate tower locations on ground conforming to the approved profile and tower schedule.
- 1.6.2 The co-ordinates of all the tower locations shall also be recorded using GPS of positional accuracy less than 3m for easy relocating. The position of all tower locations shall be marked in the final digitized route alignment drawing with relative distances from any permanent bench mark area.
- 1.6.3 The contractor shall prepare and submit soil profile along the transmission line route (in digitized form, with digitized route alignment drawing as base) indicating salient soil characteristics /features, water table etc. based on detailed soil investigations and other details / information collected during detailed survey.
- 1.7 **CONTOURING AT HILLY/UNDULATED LOCATIONS**
- 1.7.1 The levels up or down of each pit centre with respect to centre of tower location shall be recorded at intervals of 2m using total stations/GPS/digital theodolite and digitized contour plans shall be made. Based on the digitized elevation plans, the quantities of benching & protection work vis-à-vis possible unequal leg extensions shall be optimized using suitable computer-aided techniques/software.
- 1.7.2 The final tower schedule based on detailed survey of tower locations & contouring by the contractor, shall be submitted for approval of Employer. The tower schedule shall show position of all type of towers, span length, type of foundation for each tower, benching & revetment requirement, unequal leg extensions, deviation at all angles, crossings & other details etc.
- 1.8 **SURVEY METHODOLOGY & PRECISION**
- 1.8.1 All elevations shall be referenced to benchmarks established by the Survey of India. Survey operations shall begin and end at benchmarks approved by the Employer.

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- 1.8.2 During the leveling of the profile, check surveys will be effected at intervals not exceeding 50 Kms. with benchmarks of known elevations. The difference in elevations as surveyed by the contractor and as declared by Survey of India for these benchmarks shall not exceed the precision required for 3rd order surveys $e \leq 24k$ where k is the distance between benchmarks in km and e is the difference between elevations in mm.
- 1.8.3 In the absence of suitable benchmarks, the leveling shall be done by two independent leveling parties working in opposite directions along the same line. The difference in elevations between the two surveys shall not exceed the precision required for 3rd order surveys as stated above.
- 1.8.4 All important objects and features along the transmission line centerline (railways, highways, roads, canals, rivers, transmission lines, distribution lines, telephone lines etc.) shall be surveyed and located with a positional accuracy of 1:2000 between points of known horizontal position.

1.9 SURVEY REPORT

- 1.9.1 Complete BOQ of the transmission line shall be furnished in the survey report.
- 1.9.2 Each angle point location shall be shown with detailed sketches showing existing nearby permanent land marks such as specific tree(s), cattle shed, homes, tube wells, temples, electric pole/tower, telephone pole, canal, roads, railway lines etc. The relative distance of land marks from the angle points and their bearings shall be indicated in the sketch. These details shall be included in the survey report.
- 1.9.3 Information w.r.t infrastructure details available en-route, identification and explanation of route constraints, etc shall also be furnished in the Survey report and shall inter-alia include the following:
 - 1.9.4 Information regarding infrastructural facilities available along the final route alignment like access to roads, railway stations, construction material sources (like quarry points for stone, sand and availability of construction water), labour, existing transport facilities, fuel availability etc. shall be furnished in the survey report.
 - 1.9.5 All observations which the Contractor thinks would be useful to the construction of the transmission lines mentioned under scope of work are to be reported.
 - 1.9.6 Suggestions regarding the number of convenient zones (line segments / portions) in which the entire alignment can be divided keeping in view the convenience of Nigam are to be given.
 - 1.9.7 Suggestions regarding location for setting up stores during line construction in consultation with Employer's representative shall also be provided by the contractor.
 - 1.9.8 Working months available during various seasons along the final route alignment, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.
 - 1.9.9 Availability of labour of various categories and contractors of civil works shall also be reported.
 - 1.9.10 Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, P&T (name of circle), Inland navigation, Irrigation Department, Electricity Boards and Zonal railways, Divisional Forest Authorities etc.
 - 1.9.11 All the requisite data for processing the case for statutory clearances such as PTCC, Forest and Railway etc. shall be provided along with the report.
 - 1.9.12 The contractor shall also collect & report details pertaining to pollution levels envisaged along the transmission line.
 - 1.9.13 Six copies of survey reports shall be furnished by the contractor to the Employer.

1.10 WAY LEAVES AND TREE CUTTING

- 1.10.1 Any way leave which may be required by the contractor shall be arranged by the employer on intimation from the contractor, after submission of the final alignment. Proposal for way leaves and right of way shall be submitted by the contractor sufficiently in advance to enable the employer to arrange for the same. Tree cutting shall be the responsibility of the contractor in consultation with the employer during stringing.
- 1.10.2 The employer shall not be held responsible for any claim on account of damage done by the contractor or his gang to trees, crops or other property without authority from the employer.
- 1.10.3 During the course of the construction, if any obstruction is encountered from the local villagers or authorities, the contractor shall immediately notify the employer who shall take such step as may be necessary. The contractor shall also try to settle the obstruction amicably.
- 1.10.4 Payment for compensations of the value of crops, trees and other vegetation, if required to be removed towards the clearance etc. during stub setting, tower erection, stringing & also for requisite safety clearance in the right of way will be the responsibility of the employer.

1.11 GEOTECHNICAL INVESTIGATIONS

1.11.1 GENERAL

- 1.11.1.1 Employer requires that a detailed Geotechnical investigation be carried out at all tower locations to provide the designer with sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters at site, on the basis of which the foundation of transmission line towers can be classified and selected/designed rationally.
- 1.11.1.2 These specifications provide general guidelines for geotechnical investigation of normal/angle locations, including marshy locations and those affected by salt water or saltpeter.

1.11.2 SCOPE

- 1.11.2.1 The scope of work includes detailed soil investigations and furnishing bore log data at various tower locations. Based on the bore log data / soil parameter / soil investigation results, the Contractor shall recommend the type of foundations suitable for each locations and the same shall be got approved by the contractor. For other locations, trial pit is to be done in every locations for foundation classification upto foundation depth. No separate payment for trial pit shall be made.
- 1.11.2.2 These specifications cover the technical requirements for a detailed Geotechnical investigation and preparation & submission of a detailed Geotechnical Report. The work shall include mobilization of all necessary tools and equipment, provision of necessary engineering supervision and technical personnel, skilled and unskilled labour, etc. as required to carry out the entire field investigation as well as laboratory tests, analysis and interpretation of data collected and preparation of the Geotechnical Report. Contractor shall also collect data regarding variation of subsoil water table along the proposed line route. The aforementioned work shall be supervised by a graduate in Civil Engineering having at least 5 years of site experience in geotechnical investigation work.
- 1.11.2.3 Contractor shall make its own arrangements to establish the co-ordinate system required to position boreholes, tests pits and other field test locations as per the drawings/sketches supplied by Employer. Contractor shall determine the reduced levels (R.L's) at these locations with respect to benchmarks used in the detailed survey. Two reference lines shall be established based on survey data/details. Contractor shall provide at site all required survey instruments to the satisfactions and drawings. Contractor shall arrange to collect the data regarding change of course of rivers, major natural streams and nalas, etc., encountered along the transmission line route from the best available sources and shall furnish complete hydrological details including maximum velocity, discharge, highest flood level (H.F.L) scour depth etc. of the concerned rivers, major streams and nalas (canals).

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- 1.11.2.4 The field and laboratory data shall be recorded on the proforma recommended in relevant Indian Standards. Contractor shall submit to Employer two copies of field bore logs (one copy each to Employer's site and Corporate office) and the entire field records (countersigned by the Employer) soon after the completion of each boreholes/test.
- 1.11.2.5 One copy of all field records and laboratory test results shall be sent to Employer on a weekly basis. Employer may observe, at the laboratory, the testing procedures.
- 1.11.2.6 The Contractor shall interact with the Employer to get acquainted with the different types of structures envisaged and in assessing the load intensities on the foundation for the various types of towers in order to enable him to make specific recommendation for the depth, founding strata, type of foundation and the allowable bearing pressure.
- 1.11.2.7 After reviewing Contractor's geotechnical investigation draft report, Employer may call the contractor & his geotechnical engineer for discussions to be held at Employer's site office / Corporate office and give comments on the report. The report shall be redrafted & finalised by the contractor based on the comments and get the same approved from Employer's site office. All expenditure associated with the redrafting and finalising the report including traveling etc. shall be deemed to have been included in the rates quoted for the geotechnical investigations.
- 1.11.2.8 Contractor shall carry out all work expressed and implied in this specifications in accordance with requirements of the specification.

1.11.3 GENERAL REQUIREMENTS

- 1.11.3.1 Wherever possible, Contractor shall research and review existing local knowledge, records of test pits, boreholes, etc., types of foundations adopted and the behavior of existing structures, particularly those similar to the present project.
- 1.11.3.2 Contractor shall make use of information gathered from nearby quarries, unlined wells excavation etc. Study of the general topography of the surrounding areas will often help in the delineation of different types of soil.
- 1.11.3.3 Contractor shall gather data regarding the removal of overburden in the project area either by performing test excavations, or by observing soil erosion or land slides in order to estimate reconsolidation of the soil strata. Similarly, data regarding recent landfills shall be studied to determine the characteristics of such land fills as well as the original soil strata.
- 1.11.3.4 The water level in neighboring streams and watercourses shall be noted. Contractor shall make inquiries and shall verify whether there are abandoned underground works e.g. worked out ballast pits, quarries, old brickfields, mines, mineral workings etc.
- 1.11.3.5 It is essential that equipment and instruments be properly calibrated at the commencement of the work. If the Employer so desires, Contractor shall arrange for having the instruments tested at an approved laboratory at their own cost and shall submit the test reports to the Employer. If the Employer desires to witness such tests, Contractor shall arrange for the same.

1.11.4 CODES AND STANDARDS FOR GEOTECHNICAL INVESTIGATIONS

- 1.11.4.1 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between the present specifications and those referred to herein, the former shall prevail. Internationally accepted standards, which ensure equal or better performance than those specified shall also be accepted.
- 1.11.4.2 All work shall be carried out in accordance with the following Indian Standards and Codes:

Indian Standards (IS)	Title	International and Internationally Recognized Standard/Code
IS: 1080-1990	Codes of Practice for Design and Construction of Simple Spread Foundations	

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IS: 1498-1992	Classification and identification of Soils for General Engineering purposes.	ASTM D 2487/ASTM D 2488
IS: 1888-1982	Method of load tests on soil	
IS: 1892-1992	Code of Practice for Subsurface Investigation for Foundation	
IS: 1904-1986	Code of Practice for Design and Construction of foundation in Soils: General Requirements.	
IS: 2131-1992	Method of Standard Penetration Soils	ASTM D 1586
IS: 2132-1992	Code of Practice for Thin Walled Sampling of Soils	ASTM D 1587
IS: 2720-1992	Method of Test for Soils (Relevant Parts)	ASTM D 420
IS: 2809-1991	Glossary of Terms and symbols	ASTM D 653
IS: 2810-1979	Glossary of terms and symbols related to soil dynamics Relating to Soil Engineering	
IS: 2911-1980	Code of Practice for Design and construction of pile Foundations (Relevant Parts).	
IS: 3025	Methods of Sampling and Testing (Physical and Chemical) for water used in industry.	
IS: 3043-1991	Code or Practice for Earthing.	
IS: 4078-1990	Code of Practice for Indexing and Storage of Drill Cores.	
IS: 4091-1987	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.	
IS: 4434-1992	Code of Practice for in-situ Vane Shear Test for Soils.	ASTM D 2573/ASTM D 4648
IS: 4453-1992	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.	
IS: 4464-1990	Code of Practice for Presentation of Drilling Information and core description in Foundation Investigation	
IS: 4968-(Part-II)-1992	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS: 5313-1989	Guide for Core Drilling observations.	
IS: 6403-1990	Code Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.	ASTM D 194
IS: 6926-1990	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.	
IS: 6935-1989	Method of Determination of Water level in a Bore Hole.	
IS: 7422-1990	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).	
IS: 8009 (Part-I)-1993	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS: 8764-1991	Method of Determination of Point Load Strength Index of Rocks.	
IS: 9143-1991	Method of Determination of Unconfined Compressive Strength of Rock Materials.	ASTM D 2938
IS: 9179-1991	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS: 9259-1992	Specification for Liquid Limit Apparatus.	ASTM D 4318
IS: 9640-1992	Specification for Split Spoon Sampler.	ASTM D 1586
IS: 10050-1992	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS:11315-(Part-II)-1991	Description of Discontinuities in Rock Mass-Core Recovery and Rock Quality.	
	CBIP Manual on transmission line towers, Chapter – 10 Foundations	

1.11.5 BORE HOLES

Boreholes are required for soil investigations for all suspension locations.

1.11.5.1 GENERAL REQUIREMENTS

- a. Boreholes shall be made to obtain information about the subsoil profile, its nature and strength and to collect soil samples for strata identification and for conducting laboratory tests. The minimum diameter of the borehole shall be 150mm and boring shall be carried out in accordance with the provisions of IS: 1892 and this specification:
- b. All boreholes shall be minimum 3m deep for normal open cast type foundations. The depth of bore holes at river crossings and special locations shall be 40 m. If the strata with Standard Penetration Test – N value measured greater than 100 with characteristics of rock is met, the borehole shall be advanced by coring at least 3m further, in normal locations & at least 7m further for the case of river crossing locations, with prior approval of the Employer.
- c. Casing pipe shall be used when collapse of a borehole wall is probable. The bottom of the casing pipe shall at all times be above the test of sampling level but not more than 15cm above the borehole bottom. In case of cohesion less soils, the advancement of the casing pipe shall be such that it does not disturb the soil to be tested or sampled. The casing shall preferably be advanced by slowly rotating the casing pipe and not by driving.
- d. In-situ tests shall be conducted and undisturbed samples shall be obtained in the boreholes at intervals specified hereafter. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water table in the borehole shall be carefully recorded and reported following IS: 6935. No water or drilling mud shall be used while boring above ground water table. For cohesion less soil below water table, the water level in the borehole shall at all times be maintained slightly above the water table.
- e. The borehole shall be cleaned using suitable tools to the depth of testing or sampling, ensuring least or minimum disturbance of the soil at the bottom of the borehole. The process of jetting through an open tube sampler shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a flap valve. Gentle circulation of drilling fluid shall be done when rotary mud circulation boring is adopted.
- f. On completion of the drilling, Contractor shall backfill all boreholes as directed by the Employer.

1.11.5.2 AUGER BORING

Auger boring may be employed in soft to stiff cohesive soils above the water table. Augers shall be of helical or post hole type and the cuttings brought up by the auger shall be carefully examined in the field and the description of all strata shall be duly recorded in the field bore log as per IS: 1498. No water shall be introduced from the top while conducting auger boring.

1.11.5.3 SHELL AND AUGER BORING

- 1.11.5.3.1 Shell and auger boring may be used in all types of soil that are free from boulders. For cohesion less soil below ground water table, the water level in the borehole shall always be maintained at or above ground water level.
- 1.11.5.3.2 The use of chisel bits shall be permitted in hard strata having SPT-N value greater than 100. Chisel bits may also be used to extend the borehole through local obstructions such as old construction, boulders, rocky formations, etc. The requirements in Clause 1.11.5.2 shall apply for this type of boring also.

1.11.5.4 ROTARY BORING

Rotary boring method may be used in all types of soil below water table. In this method the boring is carried out by rotating the bit fixed at the lower end of the drill rod. Proper care shall be taken to maintain firm contact between the bit and the bottom of the borehole. Bentonite or drilling mud shall be used as drilling fluid to stabilize and protect the inside surface of the borehole. Use of percussion tools shall be permitted in hard clays and in dense sandy deposits.

1.11.6 STANDARD PENETRATION TEST (SPT)

- 1.11.6.1 SPTs are required for detailed soil investigation for all angle locations (min. one location in 4 km. stretch). This test shall be conducted in all types of soil deposits encountered within a borehole, to find the variation in the soil stratification by correlating with the number of blows

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required for unit penetration of a standard penetrometer. Structure sensitive engineering properties of cohesive soils and sfts such as strength and compressibility, shall not be inferred based on SPT values. No extra payment shall be made for carrying out Standard Penetration Tests. The test shall be conducted at depths as follows:

Location	Depths (m)
Normal Soils	2.0, 3.0, 5.0, 7.0, 10.0
River crossings and special Locations.	2.0, 3.0, 5.0, 7.0, 10.0 and thereafter at the rate of 3m intervals to 40 m

1.11.6.2 The spacing between the levels of standard penetration test and next undisturbed sampling shall not be less than 1.0 m. The Equipments, other accessories, procedures for conducting the test and collection of the disturbed soil samples shall conform to IS: 2131 and IS: 9640. The rods shall be straight, tightly coupled and the air release valve shall be checked. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.

1.11.6.3 The test shall be carried out by driving a standard split spoon sampler in the borehole by means of a 650N hammer falling freely from a height of 750mm for 450mm depth, recording the number of blows for every 75mm. The number of blow for the last 300mm drive shall be recorded as measured N value.

1.11.6.4 This test shall be discontinued when blow count has reached 100 or the penetration is less than 25 mm for 50 blows, whichever is earlier, or sampler starts jumping. At the level where the test is discontinued, the number of blows and the corresponding penetration shall be reported. Sufficient quantity of disturbed soil samples shall be collected from the split spoon sampler for identification and laboratory testing. The sample shall be visually classified and recorded at the site as well as properly preserved without loss of moisture content and labeled.

1.11.7 SAMPLING

1.11.7.1 GENERAL

- Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for field identification and conducting laboratory tests such as grain size (sieve) analysis, index properties, specific gravity, chemical analysis etc. Undisturbed samples shall be collected to estimate the physical strength, swelling and consolidation properties of the soil.
- All accessories and sampling methods shall conform to IS: 2132. All the representative disturbed and undisturbed samples collected in the field shall be classified at site as per IS: 1498. The specification for thin wall sampling tube and sampler heads should be as per IS: 11594.
- All samples shall be identified with date, borehole or test pit number, date of sampling, etc. It is also essential to mark an arrow pointing towards the top surface of the undisturbed sample tube as the soil in-situ. Care shall be taken to keep the core and box samples vertically, with the arrow mark directing upwards. All undisturbed samples shall be properly trimmed at one end and suitably capped and sealed with molten paraffin wax on both sides. The Contractor shall be responsible for packing, storing in a cool place and transporting all the samples from site to the laboratory within seven days after sampling with proper protection against loss and damage.

1.11.7.2 DISTURBED SAMPLES

- Disturbed soil samples shall be collected in boreholes at regular intervals. Jar samples weighing approximately 1 Kg shall be collected at 0.5m intervals starting from a depth of 0.5m below ground level and at every identifiable change of strata to supplement the boring records and at the levels of Standard Penetration Tests (SPT), obtained in a SPT sampler shall also be collected. Samples shall be stored immediately in airtight jars, which shall be filled to capacity as much as possible.
- In designated borrow areas, bulk samples, from a depth of about 0.5m below ground level shall be collected to establish the required properties for use as a fill material. Disturbed samples weighing about 25kg (250 N) shall be collected at shallow depths

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and immediately stored in polythene bags as per IS: 1892. The bags shall be sealed properly to preserve the natural moisture content of the sample and shall be kept in wooden boxes for transportation.

1.11.7.3 UNDISTURBED SAMPLES

- 1.11.7.3.1 The undisturbed soil samples shall be collected immediately after drilling and cleaning the borehole upto the desired depth. Effort shall be made that the preparations are made before hand to collect the sample after reaching to the desired depth. In each borehole undisturbed samples shall be collected at every change of strata and at depths as follows:

Location	Depths (m)
Normal Soils	1.0, 4.0, 6.0, 8.0
Special Locations	1.0, 4.0, 6.0, 8.0, 11.0 and thereafter at the rate of 3 m intervals up to 40 m

- 1.11.7.3.2 The depth interval between the top levels of undisturbed sampling and standard penetration testing shall not be less than 1.0m. Undisturbed samples shall be of 100mm diameter and 450mm in length. Samples shall be collected in a manner to preserve the structure, density and moisture content of the soil. Accessories required for sampling and sampling procedures shall conform to IS: 1892 and IS: 2132 and other related IS Codes. Undisturbed sampling in sand shall be done using compressed air technique mentioned in IS: 8763.

a. Undisturbed sampling in cohesive soil:

Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin walled sampler. In order to reduce the wall friction, suitable precautions, such as oiling the surfaces shall be taken. The sampling tube shall have a smooth finish on both surfaces and a minimum effective length of 450mm. The area ratio of sampling tubes shall be less than 12.5%. However, in case of very stiff soils, area ratio up to 20% shall be permitted. Inside clearance ratio and outside clearance ratio shall be as specified by IS code.

- b. Undisturbed samples in very loose saturated sandy and silty soils and very soft clays shall be obtained by using a piston sampler consisting of a sampling cylinder and piston system. In soft clays and silty clays, with water standing in the casing pipe, piston sampler shall be used to collect undisturbed samplers in the presence of expert supervision. Accurate measurements of the sampling depth, height of sampler, stroke and length of sample recovered shall be recorded. After the sampler is pushed to the required depth, the cylinder and piston system shall be drawn up together, ensuring that there shall not be any disturbance to the sample.

c. Undisturbed sampling in cohesion less soil:

Undisturbed samples in cohesion less soils shall be obtained as per the procedure given in IS: 8763. Compressed air Sampler shall be used to take sample of cohesion less soils below water table.

- d. The sampler should be cleaned (not rusted), oiled and connected with straight drill rods coupled tightly. The air-released valve should be checked every time before lowering the sampler. At the time of lowering the sampler it should be ensured that bore hole is cleaned, casing is not below the depth of sampling and water level in the bore hole is above the water table preferably up to ground surface if sampling is done below water table.
- e. The collected sample should be sealed on both ends of the sampler with wax. They should be given identification numbers and kept in the airtight wooden boxes. They should be transported in truck with a care that the structure of soil samples would not change due to vibration during transportation. They should be kept in a testing laboratory and should be tested within seven days or before.

1.11.8 GROUND WATER TABLE

1.11.8.3 One of the following methods shall be adopted for determining the elevation of ground water table in boreholes as per IS: 6935 and the instructions of the Employer:

- a. In permeable soils, the water level in the borehole shall be allowed to stabilize after depressing it adequately by bailing before recording its level. Stability of sides and bottom of the boreholes shall be ensured at all times.
- b. For both permeable and impermeable soils, the following method shall be suitable. The borehole shall be filled with water and then bailed out to various depths. Observations on the rise or fall of water level shall be made at each depth. The level at which neither fall nor rise is observed shall be considered the water table elevation and confirmed by three successive readings of water level taken at two hours interval.

1.11.8.2 If any variation of the ground water level is observed in any specific boreholes, the water level in these boreholes shall be recorded daily during the course of the field investigation. Levels in nearby wells, streams, etc., if any, shall also be noted in parallel. Care should be taken to ensure any abrupt change in water level in borehole and the same is recorded.

1.11.8.3 SUBSOIL WATER SAMPLES

- a. Subsoil water samples shall be collected for performing chemical analysis. Representative ground water samples shall be collected when first encountered in boreholes and before the addition of water to aid boring or drilling.
- b. Chemical analysis of water samples shall include determination of pH value, turbidity, sulphate, carbonate, nitrate and chloride contents, presence of organic matter and suspended solids. Chemical preservatives may be added to the sample for cases, as specified in the test methods or in applicable Indian Standards. This shall only be done if analysis cannot be conducted within an hour of collection and shall have the prior written permission and approval of the Employer.

1.11.9 DYNAMIC CONE PENETRATION TEST
(FOR MARSHY LOCATIONS, WITH BENTONITE SLURRY)

Dynamic cone penetration test shall be conducted with bentonite slurry to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted by driving a standard size cone attached to the bottom of a string of straight and tightly coupled drill rods to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 for 300mm penetration. The Equipment, accessories required for performing the test, test procedures, field observations and reporting of results shall conform to IS: 4968, Part-II. The driving system shall comprise of a 650 N weight having a free fall of 750mm. The cone shall be 60° and of 65mm diameter provided with vents for continuous flow of bentonite slurry through the cone and rods in order to avoid friction between the rods and soil. On completion of the test, the results shall be presented as a continuous record of the number of blows required for every 300mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300mm penetration vs. depth. On completion of the test, the results shall be presented on the performa approved by the Employer.

1.11.10 DYNAMIC CONE PENETRATION TEST WITHOUT SLURRY

The test shall be conducted for prediction of different soil strata, their relative strength or density or both. The 50mm diameter 60° cone shall be fitted loosely to the driving rod through a cone adopter. The cone shall be driven in to the soil by allowing the 650 N weight hammer to fall freely through a height of 750mm each time. The number of blows for every 75mm penetration shall be recorded. The process shall be repeated till the cone is driven to the

required depth. The penetration depth shall be limited to 5m in cohesion less soil and 10m in mixed soil with some binding material. The cone driving rods, driving head, hoisting equipment shall conform to IS: 10589. The test and report should be prepared as per guidelines of IS: 4968 (Part I).

1.11.11 VANE SHEAR TEST (REQUIRED FOR BOREHOLES WHERE UNDISTURBED SAMPLES (UDS) IS NOT POSSIBLE IN MARSHY LOCATIONS)

Field vane shear test shall be performed inside the borehole to determine the shear strength of cohesive soils, especially of soft and sensitive clays, which are highly susceptible to sampling disturbance. This test shall be conducted by advancing a four-winged vane of suitable size (75mm or 100mm diameter as per the soil condition) into the soil at the desired depth and measuring the torque required to rotate the vane. The equipments and accessories required for conducting test, test procedures and field observations shall correspond to IS: 4432. Tests may also be conducted by direct penetration from ground surface. If the cuttings at the test depth in the borehole show any presence of gravel, sand, shells, decomposed wood, etc., which are likely to influence the test results substantially, the test at that particular depth may be omitted with the permission of the Employer. However, the test shall be conducted at a depth where these obstructions cease to occur. On completion of the test, the results shall be reported in an approved Performa as specified in IS: 4434, Appendix-A.

1.11.12 FIELD INVESTIGATION FOR ROCK

1.11.12.1 ROCK DRILLING

1.11.12.1.1 If, during the investigations, large hard fragments or natural rock beds like but not limited to igneous, sedimentary and metamorphic formations are encountered, work shall proceed with core drilling methods. The equipment and procedures for this operation shall conform to IS: 1892. The starting depth of drilling in rock shall be certified by the Employer. At the end of the investigation, the hole drilled in rock shall be backfilled with grout consisting of 1 part cement and 3 parts sand by weight.

1.11.12.1.2 Drilling shall be carried out with NX size tungsten carbide (TC) or diamond tipped drill bits, depending on the type of rock and according to IS: 6929. Suitable type of drill bit (TC/Diamond) and core catchers shall be used to ensure continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn. Double and triple tube core barrels shall be used to ensure better core recovery and to retrieve cores from layers of bedrock. Water shall be circulated continuously in the hollow rods and the sludge conveying the rock cuttings to the surface shall be collected. A very high core recovery ratio shall be aimed in order to obtain a satisfactory undisturbed sample. Attempt shall be made to recover cores of 1.5m in length. Normally TC bit shall be used. Change over to a diamond bit shall require the specific written approval of the Employer, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on Contractor.

1.11.12.1.3 No drilling run shall exceed 1.5m in length. If the core recovery is less than 80% in any run, the length of the subsequent run shall be reduced to 0.75m. During drilling operations observations on return water, loss of water, rate of penetration etc. shall be made and reported as per IS: 5313.

- a. The colour of return water at regular intervals, the depth at which any change of colour of return water is observed, the depth of occurrence and amount of flow of hot water, if encountered, shall be recorded.
- b. The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fail on drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.
- c. Any heavy vibration or torque noticed during the drilling should be recorded together with the depth of occurrence.
- d. Special conditions like the depth at which grouting was done during drilling, presence of artesian conditions, loss of drilling fluid, observations of gas discharge with return water, etc., shall also be observed and recorded.

- e. All the observations and other details shall be recorded as per daily drill and reported in a performa as given in IS: 5313, Appendix A.

1.11.12.2 CORE SAMPLING

- 1.11.12.2.1 Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitably sized half round plastic channel section. Care shall be taken to maintain the direction of extrusion of sample same as while coring, to avoid stress reversal.
- 1.11.12.2.2 Immediately after withdrawal from the core barrel; the cores shall be placed in a tray and transferred to core boxes specially prepared for this purpose. The boxes shall be made from seasoned timber or any other durable material and shall be indexed on top of the lid according to IS: 4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as instructed in IS: 4464. Where no core is recovered, it shall be recorded as specified in the standard. Continuous records of core recovery and rock quality designation (RQD) are to be mentioned in the bore log in accordance with IS: 11315 (Part-II). Colour photograph of cores shall be taken. The core shall be put in sealed polythene bags. The core boxes should be transported carefully so that core should not break. They should be stored in dry place and should be sent for testing immediately.

1.11.13 LABORATORY TESTING

1.11.13.1 ESSENTIAL REQUIREMENTS

- a. Depending on the types of substrata encountered, appropriate laboratory tests shall be conducted on soil and rock samples collected in the field. Laboratory tests shall be scheduled and performed by qualified and experienced personnel who are thoroughly conversant with the work. Tests indicated in the schedule of items shall be performed on soil, water and rock samples as per relevant IS codes. One copy of all laboratory test data records shall be submitted to Employer progressively every week. Laboratory tests shall be carried out concurrently with the field investigations, as initial laboratory test results could be useful in planning the later stages of fieldwork. A schedule of laboratory tests shall be established by Contractor to the satisfaction of the Employer within one week of completion of first borehole.
- b. Laboratory tests shall be conducted using approved apparatus complying with the requirements and specification of Indian Standards or other approved standards for this type of work. It shall be checked that the apparatus are in good working condition before starting the laboratory tests. Calibration of all the instruments and their accessories shall be done carefully and precisely at an approved laboratory.
- c. All samples, whether undisturbed or disturbed shall be extracted, prepared and examined by competent personnel properly trained and experienced in soil sampling, examination, testing and in using the apparatus in conformance with the specified standards.
- d. Undisturbed soil samples retained in liners or seamless tube samplers shall be removed, without causing any disturbance to the samples, using suitably designed extruders just prior to actual testing. If the extruder is horizontal, proper support shall be provided to prevent the sample from breaking. For screw tube extruders, the pushing head shall be free from the screw shaft so that no torque is applied to the soil sample in contact with the pushing head. For soft clay samples, the sample tube shall be cut by means of a high-speed hacksaw to proper test length and placed over the mould before pushing the sample into it with a suitable piston.
- e. While extracting a sample from a liner or tube, care shall be taken to assure that its direction of movement is the same as that during sampling to avoid stress reversal.
- f. The preparation of soil samples should be conforming to guide lines of IS: 2720 (Part – I).

1.11.14 TESTS

Tests as indicated in this specification and as may be requested by the Employer, shall be conducted. These tests shall include but may not be limited to the following:-

- a. Tests of undisturbed and disturbed samples
 - Visual and engineering classification;
 - Sieve analysis and hydrometric analysis;
 - Liquid, plastic and shrinkage limits;
 - Specific gravity;
 - Chemical analysis at an interval of 15 km distance at an angle location
 - Swell pressure and free swell index determination
 - Proctor compaction test.
 -
- b. Tests of undisturbed samples:
 - Bulk density and moisture content;
 - Relative density (for sand),
 - Unconfined compression test;
 - Box shear test (for sand);
 - Triaxial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):
 - i. Unconsolidated undrained;
 - ii. Consolidated drained test;
 - Consolidation.
- c. Tests on rock samples
 - Visual classification;
 - Moisture content, porosity and density;
 - Specific gravity;
 - Hardness
 - Stake durability;
 - Unconfined compression test (both saturated and at in-situ water content)
 - Point load strength index;
 - Deformability test (both saturated and dry samples).
- d. Chemical analysis of sub soil water.

1.11.15 SALIENT TEST REQUIREMENT

- a. Tri axial shear tests shall be conducted on undisturbed or remoulded soil samples, saturated by the application of back pressure. Only if the water table is at sufficient depth so that chances of its rising to the base of the footing are small or nil, the triaxial tests shall be performed on specimens at natural moisture content. Each test shall be carried out on a set of three test specimens from one sample at cell pressures equal to 100, 200 and 300 KN/sq.m. respectively or as required depending on the soil conditions. Great care shall be taken to select the rate of shearing depending upon the soil type and drainage condition. The filter paper and the porous stone shall be cleaned and de-aired properly by boiling in

water (for a minimum of 10 minutes after reaching the boiling temperature) before commencement of each test.

- b. Direct shear test shall be conducted on undisturbed or remoulded soil samples. The three normal vertical stresses for each test shall be preferably 100, 200 and 300 KN/sq.m. and or simulating with stresses in field conditions. Cohesive soil shall be compacted to the required density and moisture content in mould and remoulded sample shall be extracted and trimmed to require size. Cohesion less soil shall be tamped in the shear box itself. The plane grid plate, perforated shall be used in shear box as per requirement of drainage condition of test. The serration of grid plate shall be at right angle to the direction of shear. The filter paper and the porous stone shall be cleaned and de-aired properly by boiling in water (for a minimum of 10 minutes after reaching the boiling temperature) before commencement of each test. The rate of shearing shall be simulating with drainage condition based upon design requirement and soil type. The density and water content of soil shall be measured in each test.
- c. Consolidation test shall have loading stages of 10, 25, 50, 75, 100, 200, 400 and 800 KN/sq.m. and simulating with stresses in field condition. For each loading stage, the settlement shall be recorded at convenient time interval till settlement is very negligible or completely over. Usually a period of 24 hours will be sufficient. While putting soil specimen in consolidation ring the unnatural voids shall not be left against the inner face of the ring. The top and bottom shall project above and below the edges of the ring to enable final trimming. The density and water content of soil sample shall be measured. Rebound curve shaft be recorded for all samples by unloading the specimen at its in-situ stress. Additional rebound curves shall also be recorded wherever desired by the Employer;
- d. Chemical analysis of subsoil shall include determination of PH value, carbonate, sulphate (both SO_3 and SO_4). Chloride and nitrate contents, organic matter, salinity and any other chemicals, which may be harmful to the foundation material. The contents in the soil shall be indicated as percentage (%).
- e. Chemical analysis of subsoil water samples shall include the determination of properties such as colour, odour, turbidity, PH value and specific conductivity both at 25°C , and chemical contents such as chlorides, nitrates, carbonates, sulphates (both SO_3 and SO_4), organic matter and any other chemical harmful to the foundation material. The contents shall be indicated as parts per million (PPM) by weight.

1.11.16 GEOTECHNICAL INVESTIGATION REPORT

1.11.16.1 GENERAL

- a) On completion of all the field and laboratory work, the Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations and test results, laboratory observations and test results, summarised test data, conclusions and recommendations. The report shall also include detailed bore logs, subsoil sections, field test results, laboratory observations and test results both in tabular as well graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc.
- b) Initially, Contractor shall submit three copies of the draft report for Employer's review. After receiving Employer's comments, if any, Contractor shall incorporate the same in the report and resubmit the revised report for approval. Ten copies of the detailed final approval report shall be submitted to Employer together with one set of reproducible of the graphs, tables etc.
- c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different types of structures.

1.11.16.2 DATA TO BE FURNISHED

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1.11.16.2.1 The report shall also include but not limited to the following:

- a) A plot plan/location plan showing the locations and reduced levels of all field test e.g. boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, etc., properly drawn to scale and dimensioned with reference to the established grid lines;
- b) A true cross section of all individual boreholes and test pits with reduced levels and co-ordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted, samples collected at different depths and the rock stratum, if encountered;
- c) Geological information of the area including geomorphic, geological structure, litho logy, stratigraphy and tectonics, core recovery and rock quality designation (RQD), quantitative description of discontinuities in rock mass along the line route etc.;
- d) Observations and data regarding change of course of rivers, velocity, flood details (including past history) etc. in the vicinity of the locations.
- e) Past observations and historical data, if available, for the area or for other areas with similar soil profile, or with similar structures in the surrounding areas;
- f) Plot of Standard Penetration Test (uncorrected and corrected N values) with depth for each test site;
- g) Results of all laboratory test summarised according to Table 4.0 (i) for each sample as well as (ii) for each layer, along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores.
- h) For all triaxial shear tests, stress vs. strain diagrams as well as Mohr's circle envelopes shall be furnished. If backpressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity (E) shall be furnished for all tests along with relevant calculations. If it is not possible to get proper $c-\phi$ values of Mohr circles, the same may be obtained from p-q plots.
- i) For all consolidation tests, the following curves shall be furnished
 - i). e vs. log p;
 - ii) e vs. p;
 - iii). Compression vs log t or Compression vs \sqrt{t} (depending upon the shape of the plot, for proper determination of coefficient of consolidation). The point showing the initial condition (e_0, p_0) of the soil shall be marked on the curves;
- j) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.
- k) In static cone penetration test, plot of penetration resistance and friction jacket resistance with depth along with log of borehole shall be shown.
- l) In field Vane shear test the calculations, results and interpretation shall be submitted
- m) A set of longitudinal and transverse soil/rock profiles connecting various boreholes in order to give a clear picture of the variation of the sub soil strata as per IS: 6065.
- n) For Rock, drilling procedure adopted, drilling parameters, core recovery, RQD, core logs, joint parameters, core boxes with proper numbering, core box photographs and water levels etc. should be furnished in the report.

Table 1.0

SUMMARY OF RESFULTS OF LABORATORY TESTS ON SOIL AND WATER SAMPLES

1. Bore hole/ test pit. no
2. Depth (m)

3. Type of sample
4. Density (kg/m³)
 - a) Bulk
 - b) Dry.
 - c) Submerged
5. Water content (%)
6. Particle Size (%)
 - a) Gravel
 - b) Sand
 - c) Silt
 - d) Clay
7. Consistency properties
 - a) LL
 - b) PL
 - c) PI
 - d) L1
8. Soil
 - a) Classification-IS
 - b) Description
 - c) Specific gravity
9. Strength Test
 - a) Type
 - b) c (Cohesion)
 - c) ϕ (angle of internal friction)
10. Consolidation Test
 - a) e_0
 - b) P_c
 - c) C_c
 - d) DP
 - e) M_v
 - f) C_v
11. Shrinkage limit (%)
12. Swell Test
 - a) S.Pr
 - b) FS
13. Relative Density (%)
14. Remarks

Notations:

- I. For type of Sample:
 - DB - Disturbed bulk soil sample.
 - DP - Disturbed samples from cutting edge of undisturbed soil sample.
 - Rm - Remoulded soil sample
 - UB - Undisturbed block soil sample
 - US - Undisturbed soil sample by sampler
 - W - Water sample
- II. For Strength Test:
 - SCPT - Static Cone Penetration Test
 - UCC - Unconfined Compression Test
 - VST - Vane Shear Test
 - Tuu - Unconsolidated Undrained Triaxial Test
 - Note: Replace T by D for Direct Shear Test
 - Tod - Consolidation Drained Triaxial Test
- III. For Others:
 - LL - Liquid Limit (%)
 - PL - Plastic Limit
 - PI - Plasticity Index
 - LI - Liquidity Index
 - C - Cohesion (kPa)
 - O - Angle of Internal Friction (degrees)
 - S - Pr. - Swelling Pressure (kPa)
 - e_0 - Initial Void Ratio
 - P_c - Reconsolidation Pressure (kPa)

- Cc - Compression Index
DP - Change in pressure (kPa)
mv - Coefficient of Volume Compressibility (m²/KN)
Cv - Coefficient of Consolidation (m²/hr)
IV. For Chemical Test
As per Specifications - Clause 1.11.18

ROCK SAMPLES

1. Drill hole no., location
2. Depth
3. Method of drilling
4. Mineral composition
5. Density
6. Moisture content
7. Specific gravity
8. Hardness
9. Sonic wave velocity
10. Slake durability index
11. Unconfined compressive strength, σ_c
 - Saturated
 - Insitu water content
12. Modulus of Elasticity, E_t
13. Poisson's ratio, ν
14. Brazilian tensile strength, σ_{tp}
15. Point load strength, σ_{lp}
16. Shear strength parameter, c, ϕ (Triaxial compression)
17. Rock joint parameters
18. Percentage core recovery
19. RQD (Rock Quality Designation)

1.11.17 RECOMMENDATIONS

1.11.17.1 Recommendations shall be provided for each tower location duly considering soil type and tower spotting data. The recommendations shall provide all design parameters and considerations required for proper selection, dimensioning and future performance of tower foundations and the following :

- a. The subsurface material must provide safe bearing capacity and uplift resistance by incorporating appropriate safety factors thereby avoiding rupture under ultimate loads;
- b. Movement of the foundation, including short and long term components under transient and permanent loading, shall be strictly controlled with regard to settlement, uplift, lateral translation and rotation:
- c. Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests. Cone resistance, fractional total resistance, relation between core resistance, Standard Penetration Test No value, and settlement analysis for different sizes of foundation based on static cone penetration test.
- d. For locations where use of shallow foundation may be required the following shall be indicated with comprehensive supporting calculations:
 - i. Net Safe allowable bearing pressure for isolated square footing of sizes 4.0, 5.0, 6.0 & 7.0 m at four different foundation depths of 1,2, 3 and 3.5 m below ground level considering both shear failure and settlement criteria giving reasons for type of shear failure adopted in the calculation.
 - ii. Net safe allowable bearing pressure for raft foundations of widths greater than 5m at 2.0, 3.0 and 4.0m below ground level considering both shear failure and settlement criteria.
 - iii. Rate and magnitude of settlement expected of the structure.

- iv. Net safe bearing capacity for foundation sizes mentioned in Para (i) above, modulus of sub grade reaction, modulus of elasticity from plate load test results along with time settlement curves in both natural and log graph, variation of Modulus of sub grade reaction with size, shape and depth of foundation.
- e. The stable slopes for shallow and deep excavations, active and passive earth pressure at rest and angle of repose for sandy soils shall be furnished. the loading of the foundations shall not compromise the stability of the surrounding subsurface materials and the stability of the foundation shall be ensured against sliding or overturning:-
- f. Depending on the subsurface material, water table level and tower type, either reinforced concrete isolated pad and chimney or any other type of foundations shall be installed at a given location
- g. Net Safe allowable bearing pressure and uplift resistance shall be provided for the various sizes of isolated square footings founded at various depths below ground level considering both shear failure and movement criteria; rate and magnitude of movement expected of the structure (settlement, uplift, rotation) shall also be given.
- h. In cases where normal open cast appear to be impractical, special pile foundations shall be given due consideration along with the following:
 - i. Type of pile foundation and reasons for recommending the same duly considering the soil characteristics.
 - ii. Suitable founding strata for the pile:
 - iii. Estimated length of pile for 500, 750 and 1000 KN and 4500 KN capacities; end bearing and frictional resistance shall be indicated separately:
 - iv. Magnitude of negative skin friction or uplift forces due to soil swelling.
- j. Where the subsoil water and soil properties are found to be chemically aggressive. Contractor shall take suitable precautions during construction including any protective coating to be applied on the foundations; susceptibility of soil to termite action and remedial measures for the same shall be dealt with;
- k. Suitability of locally available soils at site for filling, backfilling and adequate compaction shall be investigated.
- l. If expansive soil such as black cotton soil is encountered recommendation of removal or retainment of the same shall be given in the latter case, detailed specifications of special requirements shall also be given;
- m. Susceptibility of subsoil strata to liquefaction in the event of earthquake and remedial measures, if required, shall be considered.
- n. Any other information of special significance such as dewatering schemes, etc., Which may have a bearing on the design and construction, shall be provided.
- o. Recommendations for additional soil investigations, beyond the scope of the present work, shall be given if Contractor considers such investigations necessary.

1.11.18 HYDRO GEOLOGICAL CONDITIONS

1.11.18.1 The maximum elevation of ground water table, amplitudes of its fluctuations and data on water aggressivity with regard to foundation structure materials shall be reported. While preparing ground water characteristics the following parameters should be specified for each aquifer:

- a. bicarbonate alkalinity mg-eq/(deg),
 - b. pH value
 - c. content of aggressive carbon dioxide, mg/l;
 - d. content of magnesia salts. mg/l, recalculated in terms of ions Mg^{2+}
 - e. content of ammonia salts, mg/l, recalculated in terms of ions NH_4^+
 - f. content of caustic alkalis, mg/l, recalculated in terms of ions Na^+ and K^+
 - g. contents of chlorides,mg/l, recalculated in terms of ions Cl^-
 - h. contents of sulphates, mg/l, recalculated in terms of ions SO_4
 - i. aggregate content of chlorides, sulphates, nitrates, carbonates and other salts, mg/l.
-

CHAPTER - 2**TOWERS AND ACCESSORIES**

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CHAPTER - 2**TOWERS AND ACCESSORIES****2.1 SCOPE OF WORK****2.1.1 This specification covers**

- (i) Fabrication, Proto inspection, Galvanizing and inspection & testing, supply of 400 kV double circuit transmission line towers and their required body extensions as per employer design including bolts, nuts and washers, anti theft type bolts & nuts, hangers, D-shackles, U-Bolts, bird guards and bird flappers (if required) of appropriate design if identified during the ESAI study (if conducted) or mentioned in Approvals to be received from Forest Department for given line sections as a necessary accessories anti-climbing devices, flat washers etc. and also all types of tower accessories like phase plates, number plates, danger plates, circuit plates, anti-climbing devices for all types of towers & their body extensions, design & supply of extensions (if not available with employer) and special tower. The scope also covers supply of other line material like insulator, hardware, accessories, Conductor , OPGW etc. (as per the bidding schedules) and also survey, check survey, foundation, erection, testing and commissioning of 400kV transmission line.

The scope of bidder also includes manufacturing, engineering, inspection & Testing at manufacturer's works for supply of material at site i.e. Disc insulators/Long Rod Insulators, hardware fittings for conductor , ACSR Moose Conductor and other line accessories etc.

- (ii) detailed survey, profiling, tower spotting/ optimisation of tower locations, soil resistivity measurement, geo-technical investigation and check survey;
- (iii) supply of Disc insulators, GSS Earth wire, 24 Fiber (DWSM) OPGW fibre optic cable, Joint box (24 Fibre), Hardware set for 24 Fibre OPGW Fibre Optic cabling including all cable fittings & accessories, Hardware fittings for conductor & Earth wire and other line accessories,
- (iv) selection of foundations for different types of towers and casting of foundation for tower footings as per employer's design and design of foundation for extension of tower (if not available with employer) and special towers for different type of soil conditions,
- (v) erection of towers, tack welding of bolts and nuts including supply and application of zinc rich primer and enamel paint, tower earthing, fixing of insulator strings, stringing of conductor, earth wire and OPGW fiber optic cable along with all necessary line accessories,
- (vi) design, manufacturing, testing, supply and erection of aviation items including painting for day & night visual aids
- (vii) testing and commissioning of erected transmission line and
- (viii) other items not specified above but required to complete the work.

- 2.1.2 RVPN shall provide structural drawings of following types of towers & their body extensions for use in 400 kV double circuit line to the Contractor within one month after the placement of award.

Tower type	Their extensions.
Tower type DA	+ 3 M, + 6M, +9 M
Tower type DB	+ 3 M, + 6M and +9 M
Tower type DC	+ 3 M, + 6M and +9 M
Tower type DD/DE	+ 3 M, + 6M, +9 M, +18 M and +25 M

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The contractor shall erect the 400 kV double circuit line covered under this specification by using the above types of tower and their body extensions. The contractor shall fabricate proto type towers, one each of above types of tower and body extensions, assemble them and get inspected for checking of fabrication accuracy i.e. dimensions and angles etc. and workmanship by the employer's representative. However, other types of body extensions of D/C towers and special type of towers, if required as per requirement of site conditions, the same shall also be supplied by the contractor after designing, fabricating, assembling and proto inspection & testing. The foundation designs /drawings for above types of towers shall be provided by RVPN to the contractor for adopting the same in execution of the line. The volume of excavation and concrete & weight of Steel required to be used for different types of foundations are available at Annexure-B2 (Foundation).

Other type of foundation design/ drawings, which are not available with employer, shall also be developed by the contractor-

- 2.1.3 The weight of towers, their extensions, etc., bolts & nuts and volume of excavation, concrete & weight of steel required for different types of foundations are indicated in the respective price schedule shall be ceiling weight for payment purpose.
- 2.1.4 (a) The various works are described in the different sub-section of Volume-II of this technical specification.
- (b) The unit rates quoted shall include minor items/details which are obviously and fairly intended, and which may not have been included in these documents but are essential for the satisfactory completion of the various works.
- (c) The unit rate quoted shall be inclusive of deployment of all plant equipment, men, material, skilled and unskilled labour etc. essential for satisfactory/successful completion of various works.
- (d) All measurements for payment shall be in S.I. units. Lengths shall be measured in metres corrected to two decimal places. Areas shall be computed in square metres and volume in cubic metres, rounded off to two decimals.
- (e) The item viz. Pack washers, D-shackles, U-Bolt, Bird Guard, hangers and special bolts etc . shall be the part of the tower material.
- (f) The rate of special tower inclusive of proto assembly shall be the same as quoted for normal towers.
- 2.1.5 The scope of bidder also includes manufacturing, engineering, inspection at manufacturer's works for supply of material at site i.e. bolts & nuts, Anti theft type bolts & Nuts, Disc insulators, GSS earth wire, OPGW fiber optic cable and their hardware fittings for double 'I ' suspension, single & twin tension and pilot strings for conductor & Earthwire and OPGW fiber optic cable etc. and other line accessories as detailed in the separate chapters of this specification.
- The Bidder shall clearly indicate in their offer, the source from where they propose to procure these materials. However, the overall responsibility shall be of the Contractor and he shall be responsible for the quality and workmanship of the material etc.
- 2.1.6 All the raw materials such as steel, zinc for galvanising, reinforcement steel and cement for tower foundations, coke and salt for tower earthing etc., bolts, nuts, washers, D-Shackles, hangers, links, danger plates, phase plate, number plates, circuit plates, bird guard, anti-climbing devices etc, required for tower manufacture and erection shall be included in the Contractor's scope of supply. Bidder shall clearly indicate in the offer, the sources from where he proposes to procure the raw materials and the components.
- 2.1.7 The entire stringing work of conductor and earthwire shall be carried out by tension stringing technique. The Contractor shall indicate in their offer, the sets of tension stringing equipment he is having in his possession and the sets of stringing equipment he would deploy at site exclusively for this project. However, the Bidder having requisite experience has freedom to use helicopter for construction and stringing at his risk and cost.

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- 2.1.8 Special towers may be required for crossing of river, valley etc. Bidder shall also design and provide the structural drawings, bill of materials and shop drawings of these river crossing towers to the Employer for approval. The rates of special towers inclusive of proto assembly shall be the same as quoted for normal towers.
- 2.1.9 Foundation design for special towers and the casting of the same shall also be in the scope of the Bidder. In case of pile type foundations, if the Bidder does not have necessary experience, some other qualified agency may be engaged by the bidder for design and casting of pile foundations. However, the overall responsibility shall be of the contractor and he shall be responsible for all the necessary co-ordination with the pile foundation contractor including stub-setting.

2.2 STANDARDS

- 2.2.1 Except where otherwise specified or implied the design, manufacturing, fabrication, galvanization and testing of towers shall conform to the provisions of IS: 802 (Part I/Sec I) and IS: 802(Part-II) and IS: 802(Part-III) (as amended upto date).
- 2.2.2 The Indian Standard (IS) mentioned below as amended upto date shall be applicable to the materials and process used in the manufacture of towers and tower accessories.

1	IS:209	Specification for zinc ingot.
2	IS:2062	Specification for steel for general structural purposes.
3	IS:432	Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement.
4	PART – I	Mild Steel and Medium Tensile Steel Bars.
	IS:456	Code of Practice for Plain and reinforced concrete.
5	IS:808	Specification for dimensions for hot rolled Steel Beam, Column Channel and Angle Sections.
6	IS:1200	Method of Measurement of Building and Civil Engineering Works.
7	PART – 1 & 2	Earthwork & Concrete work
	IS:1573	Specification for Electro-Plated Coating for Zinc on Iron and Steel.
8	IS:1893	Criteria for Earthquake Resistant Design of Structures.
9	IS:2016	Specification for Plain Washers.
10	IS:2551	Danger Notice Plates.
11	IS:2629	Recommended Practice for Hot-Dip Galvanising of Iron & Steel.
12	IS:3063	Fasteners – Single Coil Rectangular Section, Spring Washers.
13	IS:2633	Methods for Testing Uniformity of Coating on Zinc Coated Articles.
14	IS:4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.
15	IS:4759	Specification for Hot-Dip Zinc Coatings on Structural Steel and Other Allied Products.
16	IS:5613(Part-3)	Code of Practice for Design, Installation and Maintenance of Overhead Power Lines: 400 kV lines.
17	Section 1	Design
	Section 2	Installation and Maintenance.
	IS:6610	Specification for Heavy Washers for Steel Structures.
18	IS:6639	Specification for Hexagonal Bolts for Steel Structures.
19	IS:6745	Specification for Method for Determination of mass of Zinc Coating on Zinc Coated Iron and Steel Articles.
20	IS:7215	Specification for Tolerances for Fabrication of Steel Structures.
21	IS:8500	Specification for Structural Steel – micro alloyed (Medium and High Strength qualities).
22	IS-1489	Portland Pozzolana cement.

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23	IS-1363	Hexagonal head bolts, screws and nuts of product grade-c
24	Part-1	Hexagonal head bolts
	Part-3	Hexagonal nuts
25	IS-1367	Technical supply conditions for threaded steel fasteners.
	Part-3	Mechanical properties & Test methods for bolts, screws & studs with fully load-ability.
	Part-6	Mechanical properties & Test methods for nuts with specified proof loads.
	Part-13	Hot Dip Galvanized Coatings on threaded Fasteners.
	IS-1269	43 Grade ordinary Portland cement.
26	IS-800	Code of Practice for General Building Construction in Steel
27	IS-802	Code of Practice for Use of Structural Steel in Overhead Transmission Line Towers
28	IS-875	Code of Practice for Design Loads (Other than Earthquakes) for Buildings and Structures.
29	IS-1477	Code of Practice for Painting of Ferrous Metals in Buildings.
30	IS-1786	High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
31	IS-1852	Rolling and Cutting Tolerances of Hot Rolled Steel Products.
32	IS-2074	Ready Mixed Paint, Air Drying, Red Oxide, Zinc Chrome, Priming Specifications
33	IS-3043	Code of Practice for Earthing.
34	IS-3757	High Strength Structural Bolts.
35	IS-5369	General Requirements for Plain Washers.
36	IS-6623	High Strength Structural Nuts.
37	IS-10238	Step Bolts for Steel Structures.
38	IS-12427	Bolts for Transmission Line Towers.
39		Indian Electricity Rules
40	Publication No.19(N)/700	Regulation for Electrical crossing of Railway Tracks

- 2.2.3 The material manufactured as per any other internationally accepted standards which ensure an equal or higher quality than Indian Standards shall also be accepted. A copy of such standards in English Version shall be enclosed with the bid. If any standard is revised/updated to new standard number then same shall be applicable.

2.3 MATERIALS AND WORKMANSHIP

- 2.3.1 All materials used in the manufacture of the tower and tower accessories shall be conforming to relevant standards given in Clause 2.2.

2.4 GENERAL DESCRIPTION OF THE TOWERS

- 2.4.1. The towers are of the following types:

- a) Double circuit (DA, DB, DC and DD)
- b) Special towers

- 2.4.2. The towers are of self supporting lattice steel type designed to carry the line conductor with necessary insulators, OPGW and earth wire, and all fittings under all loading conditions. Outline diagram of double circuit tower is enclosed with specification.

- 2.4.3 The tower shall be fully galvanised structure. The most efficient grade of structure steel angle sections and plates shall be used in order to yield the lowest in package of combined tower and foundation cost. The type and grade of steel shall conform to latest applicable national/international standards.

2.4.4 TYPE OF TOWERS

- 2.4.4.1. The towers are classified as given below:

Type of Tower	Deviation Limit	Typical Use
DA	0 deg – 2 deg.	i) To be used as tangent tower.
DB	0 deg – 15 deg	i) Angle towers with tension insulator string. ii) Also to be used for uplift force resulting from an uplift span upto 200 m under broken wire condition. iii) Also to be used for Anti Cascading Condition.
DB	0 deg	i) To be used as Section Tower.
DC	15 deg-30 deg	i) Angle tower with tension insulator string. ii) Also to be used for uplift forces resulting from an uplift span upto 200 m under broken wire condition. iii) Also to be used for anti cascading condition.
DC	0 deg	i) To be used as section tower.
DD	30 deg-60 deg	i) Angle tower with tension insulator string. ii) Also to be used for uplift forces resulting from an uplift span upto 300 m under broken wire condition. iii) for river crossing anchoring with longer wind span & 0 deg. Deviation on crossing span side and 0 deg. to 30 deg. Deviation on other side.
DE	0 deg.	i) Dead end with 0 deg. to 15 deg. Deviation both on line side and sub-station side (slack span)

Note: The above towers can also be used for longer span with smaller angle of deviations

2.5 EXTENSIONS

- 2.5.1 For power line crossing 18 M and 25M extensions with tangent type tower may be required. Bidders shall state in their Bid the maximum reduced span for which standard tower with 18 metre and 25 metre extension can be used with the stipulated factor of safety. 25-metre extension should be designed in such a manner that the same can also be used as 18-metre extension to normal tower after removal of bottom panels.

2.6 SPECIAL TOWERS

- 2.6.1 Special towers may be required for major river crossings or for very long spans. The supply of these special towers is also included in the scope of this specification if required.

2.7 CONFIGURATION OF TOWER AND TYPE OF CONNECTIONS

- 2.7.1 Bids shall be submitted for the tower configurations as given in Drg.No SE/400 kV Purchase/001.
- 2.7.2 All member connections used in the towers, special towers, and extensions shall be of bolted type.

2.8 TRANSPOSITION TOWERS

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'C' type towers (section towers) with suitable modifications are to be used for transposition of the line, if required, maintaining all the required clearances and shielding. Numbers of transposition locations shall be two. These towers shall be supplied complete with all fittings and fixing arrangements as necessary for achieving transposition.

2.9 TOWER DESIGN: SPECIAL TOWERS/EXTENSIONS OF TOWERS

Towers are designed as per latest IS: 802 (Part1/Sec1) for Wind zone = 4 (47 m/s, i.e. 170 km/h), reliability level=1, terrain category=2. The suspension tower will be designed for 75% of full wind in security condition.

2.9.1 CONDUCTOR AND GROUND WIRE CONFIGURATION

2.9.1.1 For 400 kV double circuit towers, the phases shall be in vertical formation.

2.9.1.2 One number galvanised stranded steel wire and one number OPGW shall be used as ground wire for towers. These shall be continuous and shall be provided above conductors at suitable elevation to offer effective shielding and mid span clearances.

2.9.1 Span and clearances

2.9.1.1 Normal Span

The normal ruling span of the line is 400m for 400 kV line.

2.9.1.2 Wind Span

The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal ruling span.

2.9.1.3 Weight span

The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. For spotting of structures, the span limits for 400 KV lines shall prevail.

Tower type	Normal Condition		Broken wire Condition	
	MAX (m)	MIN (m)	MAX (m)	MIN (m)
DA	600	200	360	100
DB	600	0	360	(-) 200
DC	600	0	360	(-) 200
DD	600	0	360	(-) 300

2.9.1.4 In case at certain locations where actual spotting spans exceed the design spans and cross-arms and certain members of towers are required to be modified/reinforced, in that case drawings for the modified/reinforced towers will also be developed by the Contractor as per requirement.

2.9.1.5 Electrical Clearances

2.9.1.6 Ground Clearance

The minimum ground clearance from the bottom conductor shall not be less than 8840 mm for 400 kV lines at the maximum sag conditions i.e at 85° C and still air.

- An allowance of 150mm shall be provided to account for errors in stringing.
- Conductor creep shall be compensated by over tensioning the conductor at a temperature of 26°C lower than the stringing temperature for ACSR "Moose" conductor for 400 kV transmission line.

2.9.1.7 Electrical System Data for 400 kV line

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1.	Nominal Voltage	kV	400
2.	Maximum system voltage	kV	420
3.	BIL (Impulse)	kV (Peak)	1550
4.	Power frequency withstand voltage (Wet)	kV (rms)	680
5.	Switching surge withstand voltage (Wet)	kV (rms)	1050
6.	Minimum Corona extinction voltage at 50 Hz AC system under dry condition	kV (rms) phase to earth.	320(Min)
7.	Radio interference voltage at one MHz for phase to earth voltage of 305 KV under dry condition.	Micro Volts	1000 (Max)

2.9.1.8 Details of line Materials:

Sl. No.	Description	Conductor	Earthwire
1.	Type	ACSR 'Moose' conductor	7/3.66mm GS Earthwire
2.	Stranding and wire diameter		
	Aluminium	54/3.53	-
	Steel	7/3.53	7/3.66
3.	Conductor per phase	4	NA
4.	Spacing between conductor of same phase(sub conductor spacing)(mm)	457	NA
5.	Configuration	Vertical	Two/One continuously to run horizontally on top of the towers and conductors.
6.	Overall Diameter (mm)	31.77	10.98
7.	Unit mass (kg/km)	2004	583
8.	Min. UTS (kN)	161.22	68.4
9.	Ruling design span (Meters)	400	400

Note: Conductor to be supplied by the Employer & Steel Earthwire by the Contractor

2.9.2 LOADS ON TOWER

As per latest IS:802 (Part1/Sec1).

2.10 TOWER STEEL SECTIONS

2.10.1 Steel Sections for towers to be used in towers, extensions, special towers, stubs and stub setting templates shall be of tested quality conforming to IS-2062: 2006 of grade E 250 & yield strength 2550 kg/cm² for mild steel and IS-2062: 2006 of grade E 350/BSEN 10025 grade 355 JR & yield strength 3565 kg/cm² for high tensile steel.

2.10.2 The successful bidder shall furnish section-wise requirement of M.S. and High Tensile Steel for each type of tower, after proto assembly of the respective type of tower.

2.11 THICKNESS OF MEMBERS

2.11.1 The minimum thickness of angle sections used in the design of towers shall not be less than the following values:

- (a) Leg members and all members of cross- arm.- 5 mm
- (b) For all other members. - 4 mm

2.12 PERMISSIBLE STRESSES

2.12.1 AXIAL STRESS IN TENSION

The estimated tensile stresses on the net effective sectional area in various members multiplied by appropriate factor of safety shall not exceed minimum guaranteed yield stress of the material.

2.12.2 AXIAL STRESS IN COMPRESSION

Axial stresses in compression in various members shall be computed in accordance with Clause No.9.2 of IS 802 (Part-I) .

2.12.3 STRESS IN BOLTS

2.12.3.1 The estimated stresses in bolts multiplied by the appropriate factor of safety shall not exceed the value given below:

Nature of Stress	Permissible Stress for Bolts of Property Class 5.6 (MPa)
Shear Stress on gross area of bolts	310
Bearing Stress on gross diameter of bolts.	620
Tension Axial tensile stress	250

2.12.3.2 High strength bolts used shall conform property class 8.8 of IS:3757, where higher strength bolts are used with the material of lower grade, the bearing strength of bolt shall be limited to the bearing strength of lower grade material.

2.13 SLENDERNESS RATIOS

2.13.1 Compression Members - The slenderness ratios of compression members shall be determined as follows:

TYPE OF MEMBERS		VALUE OF KL/r
(a)	Leg sections or joints members bolted in both faces at connections for $0 < L/r \leq 120$.	L/r
(b)	Members with concentric loading at both ends of the unsupported panel connections for $0 < L/r < 120$.	L/r
(c)	Members with concentric loading at one end and normal framing eccentricity at the other end of the unsupported panel for $0 < L/r < 120$	$30 + 0.75 L/r$
(d)	Members with normal framing eccentricities at both ends of the unsupported panel for $0 < L/r < 120$.	$60 + 0.50 L/r$
(e)	Members unrestrained against rotation at both ends of the unsupported panel for $120 < L/r \leq 200$.	L/r
(f)	Members partially restrained against rotation at one end of the unsupported panel for $120 \leq L/r \leq 225$.	$28.6 + 0.762 L/r$
(g)	Members partially restrained against rotation at both ends of the unsupported panel for $120 \leq L/r \leq 250$.	$46.2 + 0.615 L/r$
(h)	Redundant Members for $0 < L/r < 250$	L/r

2.13.1.1 A single bolt connection shall not be considered as offering restraint against rotation. A multiple- bolt connection properly detailed to minimize eccentricities shall be considered to offer partial restraint if connection is made to a member having adequate flexural strength to resist rotation of the joint. Points of intermediate support shall not be considered as offering restraint to rotation unless they meet the criteria outlined above.

2.13.1.2 In the design of members, the length L shall be from centre to centre of intersection of CG line as shown in the line diagram of tower at each end of the member.

2.13.1.3 The limiting value of KL/r shall be as follow:

Leg members and lower members of the cross arms in compression	120
Other members carrying computed stresses	200
Redundant members and those carrying nominal stresses.	250

- 2.13.1.4 Secondary members shall be checked for axial compressive load of 2.5% of the ultimate load of member to which it connects. Also the slenderness ratio shall be limited to 250 as normally followed for secondary members.

2.13.2 TENSION MEMBERS

The Slenderness ratio of a member carrying axial tension only shall not exceed 400.

2.14 TOWER DESIGNS AND WEIGHTS

- 2.14.1 The weights of double circuit towers and their extensions (as per design to be provided by RVPN) are given in Schedules of Prices and the same shall be treated as ceiling weights for payment purposes. However, the weight of each type of tower extensions (to be designed by the bidder) shall also be given by the bidder, if required in the Schedules of Prices and the same shall be treated as the ceiling weight for payment purposes.

- 2.14.2 The Contractor shall submit to the Purchaser, for his approval the detailed design calculations, drawings for special towers and types of body extensions of D/C towers required if any as per site requirement

The black weights of tower (s) shall be calculated by using the standard sectional weights of steel structure of the sizes indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weight due to drilling of bolt holes, skew cuts, chamfering etc. or increase in weight due to galvanization but taking into consideration the weight of bolts, nuts, washers, hangers, D-Shackles, 'U' bolts, strain plates etc.

If, the weight of the finally approved and accepted tower is less than guaranteed weight as given in his bid, the weight which is lower shall form the basis of payment.

- 2.14.3 While designing towers extensions (if not available with employer) and special towers, the Contractor shall use only such sizes of steel structures which are easily procurable. If for any reason, the sections approved are not easily procurable, the Contractor will be responsible to procure the alternative sizes which are satisfactory from the point of view of design, fabrication, galvanisation and supply the same at no additional cost to the Employer.

- 2.14.4 The designs/ structural drawings/BOM/ shop sketches of all types of towers, their body extensions and special towers, required if any against the order shall be property of NIGAM and shall under no circumstances be shown or given to third parties without consent of NIGAM. All legal rights in this respect are reserved by NIGAM.

- 2.14.5 The contractor will submit hard copy alongwith soft copies of design of towers, structural drawings, shop sketches, Bill of Materials, tower spotting data, sag tension calculations, sag template, foundation designs, foundation drawings etc. to the Employer.

2.15 ERECTION STRESSES

- 2.15.1 Where erection stresses combined with other possible co-existent stresses could produce a working stress in any member appreciably above the permissible stress, such additional strengthening of the member shall be affected or such other provision made as is necessary to bring the working stress within the permissible limit.

2.16 CLEARANCES

2.16.1 GROUND CLEARANCE

The minimum ground clearance from the lowest conductor shall be considered as given in Sub- Section I.

- 2.16.2 The following provisions are made for considering the ground undulations, errors in stringing and creep on conductors.

- (i) 150 mm towards ground undulation and errors in stringing.

- (ii) Temperature compensation by increasing the stringing tension by way of reducing the stringing temperature by 26 Deg.C.

The Bidder shall make necessary provision to cater for the above requirement.

- 2.16.3 No creep compensation shall be provided in case of Galvanized stranded steel ground wire.

2.17 CLEARANCES OF LIVE PARTS TO TOWER MEMBERS

- 2.17.1 The minimum clearances between the live parts, tower and cross-arm members have been given in Sub- Section I. Whenever necessary the jumper loops at tension towers may be weighed with the approval of the Employer with suitable weights to reduce the angles of swing and provide necessary air clearances under wind conditions. For the purpose of computing the clearances, the dimensions of insulator strings as given in Chapter-7 and Drawing Nos. SE/400 kV Purchase/002 to SE/400 kV Purchase/006 of this specification may be assumed together with standard arcing horns. The design of the towers shall be such that it would satisfy all the above conditions when clearances are measured from any live point of the strings.
- 2.17.2 The clearances at all the cross-arms for specified swing angles of the insulator strings shall also be checked for single suspension string for towers. However, the height of tower at cross arm shall be fixed for single suspension.

2.17.3 MIDSPAN CLEARANCE

- 2.17.3.1 The minimum vertical mid-span clearance between ground wire and the nearest power conductor shall not be less than the value specified in Sub Section I. The minimum vertical mid-span clearance shall mean the vertical clearance between ground -wire and the nearest conductor under all temperatures conditions and still air in the normal ruling span. The ground - wire sag shall not be more than 90 percent of the corresponding sag of power conductor under still air conditions for the entire specified temperature range.
- 2.17.4 The successful Bidder in consultation with the insulator and hardware suppliers shall verify the string length and ensure that the specified clearances and other relevant requirements are fully met and shall submit the final clearances diagrams based on the exact lengths of insulator strings for approval of the Employer.

2.18 NUMBER OF PARTS

- 2.18.1 Tower members shall be so fabricated as to be bolted together easily at site. Preference will be given to the Purchase with least number of parts and the one which offers best facilities for transport, erection and maintenance. In designing towers for a minimum number of parts, the Contractor shall not, however, employ parts of such dimensions as will prove difficult to handle, The length of the longest piece shall be 6 meters approximately.

2.19 ATTACHMENT FOR INSULATOR STRINGS AND GROUND -WIRE CLAMPS

- 2.19.1 The cross-arms on the suspension towers shall be provided with suitable shackles of approved design made of forged steel of adequate strength for the attachment of suspension insulator strings.
- 2.19.2 On tension towers, strain plates of suitable dimensions and adequate strength shall be provided on the underside of cross-arm for attaching the tension insulator strings.
- 2.19.3 Provision shall be made on the towers for the attachment of ground -wire suspension and tension clamps. Four holes shall be provided on the bent plate at ground -wire peak, with each pair of holes perpendicular to the other to accommodate 'U' Bolt either along or transverse to the line direction as shown in Drawing No. SE/400 kV Purchase/015. The design of attachments shall be suitable for ground -wire peak without any modifications. Full details of attachments shall be given in the Bid and modification, if any, needed based on the type of clamps shall be carried out without any extra cost.
- 2.19.4 Holes shall be provided on the ground -wire peak for connecting the ground -wire to towers using an earthing bond for good electrical connections.

2.20 GROUNDING OF TOWERS

- 2.20.1 Grounding of towers shall be done in accordance with IS: 5613(Part 3/Section 2).
- 2.20.1.1 The angle of shielding is defined as the angle formed by the line joining the center lines of the ground -wire and power conductor/outer power conductor, in still air, at tower, to the vertical line through the center line of the ground -wire. The angle of shielding to be maintained for the design of transmission lines under the project has been specified in Sub-Section I. The drop of 150mm on account of ground wire suspension assembly shall be considered while calculating the minimum angle of shielding.
- 2.20.2 Two 17.5 mm dia holes shall be drilled about 50mm apart of all stubs such that the lower hole is about 150 mm above the ground level, clear of the concrete muffing, for connecting the earth strip.
- 2.20.3 The Bidder shall quote for the supply of grounding materials complete with galvanised mild steel strip, necessary bolts, nuts and washers required for connecting the strip to pipe and the tower.
- 2.20.4 Counterpoise earth, where necessary shall be provided by the Contractor in accordance with IS: 5613(Part 3/Section2).
- 2.20.5 The Bidder shall quote unit rates for the pipe type and counterpoise earthing.

2.21 STEP BOLTS AND LADDERS

Two of the diagonally opposite legs shall be provided with step-bolts which shall conform to the provisions of IS: 5613 (Part 3/Section 2). Each step bolt shall be provided with two nuts on one end and a button head at the other to prevent slipping of feet. The step-bolts shall be capable of withstanding a vertical load of not less than 150 kg. assumed as a distributed load acting over 175 mm length of the bolt from the button head end. Each tower shall be provided with step bolts conforming to IS:10238 of not less than 16 mm dia., 50 mm head and 175 mm long, spaced about 3.0 mtr. above the ground level to the top of the tower.

- 2.21.2 In the case of special structures, if the height of superstructure exceeds 60 metres, ladder alongwith protection rings of approved design shall be provided in continuation of the step-bolts on the longitudinal face of the tower. from 60 metres above ground level to the top of the special structure. Suitable platforms using flats and chequered plates not less than 6mm thick alongwith suitable railing for access from step-bolts to the ladder and from the ladder to each cross-arm and the ground wire support shall also be provided.

2.22 NUMBER PLATES, DANGER PLATES, CIRCUIT PLATES & PHASE PLATES AND BIRD GUARD

- a) Each tower shall be fitted with a number plate, phase plate, circuit plates & danger plate. All towers should have the provision of fixing these accessories on the transverse face. The arrangement for fixing these accessories shall not be more than 4.5 m above the ground level.
- b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS: 2551 and shall be in a signal red on the front of the plate.
- c) The corners of the number and danger plate shall be rounded off to remove sharp edges.
- d) The letters of number and circuit plates shall be red enameled with white enameled background.
- f) Six Nos. Saw tooth type bird guards should be provided for each tower type DA, conforming to IS: 5613 (part-2, Sec-1).

2.23 ANTI-CLIMBING DEVICE

- 2.23.1 Towers shall be fitted with anti-climbing devices of spike type as per Drawing No SE/400kV Purchase/016 and conform to IS: 5613 (Part 3/Section 1). The height of the anti-climbing device shall be provided approximately 2.5 to 3.5 meter above ground level.

2.23.2 Necessary holes shall be provided on the tower members for installation of the anti-climbing device.

2.23.3 The Bidder shall quote unit rate for anti- climbing device inclusive of structure and bolts and nuts.

2.24 DESIGN OF FOUNDATION

2.24.1 SCOPE

2.24.1.1 This section covers the design requirements of reinforced cement concrete foundations of self supporting galvanised lattice towers for 400 kV D/C Transmission line in respect of towers, special towers & body extensions of all types of towers which may be required as per necessity of the site.

2.24.1.2 The payment for different items of foundations shall be restricted to guaranteed volumes quoted in the schedules or actual whichever is less, as per unit rates.

2.24.2 CLASSIFICATION OF SOILS

2.24.2.1 Classification of soils for which foundations are to be designed shall be in accordance with latest edition of IS: 1200 (Part.I), IS: 5613(Part.3/Section.2) and IS: 1498.The foundations shall generally be designed for following type of soils:

a)	Normal Soil (ND)
b)	Hard soil mixed with boulders
c)	Wet/Sandy soil
d)	Wet Back Cotton Soil (WBC)
e)	Soft/Disintegrated Rock (DFR).
f)	Submerged Fissured Rock (SFR)
g)	Hard Rock.
h)	Wet Fissured Rock (WFR)
i)	Partially Submerged Soil.
j)	Fully Submerged Soil.

2.24.2.2 Type of soil to be encountered en-route proposed Transmission Line shall generally be normal dry in nature. Disintegrated/soft rock may also be encountered at few locations. The physical properties of normal dry soil which shall be required for the design of foundations are given in Sub-Section-I. Bidder shall confirm that in case other types of soils, other than dry, is encountered at any location he shall also develop the designs of foundations for such soils as per site conditions. The rates quoted by him for various items of foundation work viz excavation, concrete, reinforcement etc. shall also be applicable for such foundations.

2.24.3 GROUPING AND CLASSIFICATION OF FOUNDATIONS

2.24.3.1 The foundations for normal towers and normal towers with the extensions shall be grouped as under

- a) Normal Towers.
- b) Normal Towers with 3.0 m, 6.0m and 9.0m extensions.
- c) Normal Towers with 18.0m & 25.0 m extensions.

2.24.3.2 The design of foundation for normal tower with +18M & +25M extensions shall be developed based on critical loading in a group and the same shall be adopted for all towers in that group. However, the said design shall be checked for its adequacy and safety for other towers in that group. Only one design of foundation shall be adopted for each group for a particular soil condition.

2.24.3.3 Depending on the location of water table, the foundations shall be further classified as Dry, wet, partially submerged and Fully Submerged as defined in IS: 5613(Part-3/Section-2) and as under:

a) **NORMAL DRY FOUNDATION**

Dry Foundation shall be that where sub-soil water is met below the foundation base i.e. below foundation base founding level.

b) **WET FOUNDATION**

Wet Foundation shall be that where sub-soil water rises in the foundation pit upto 1.5 m below ground level: or where there is water over the ground for long periods but does not penetrate beyond 1.0 m below ground at such paddy fields.

c) **PARTIALLY SUBMERGED FOUNDATION**

Partially submerged Foundation shall be that where sub-soil water rises in the foundation pit upto 0.75 m to 1.5 m below ground level.

d) **FULLY SUBMERGED FOUNDATION**

Fully submerged Foundation shall be that where sub-soil water rises in the foundation pit within 0.75 m below ground level.

e) **BLACK COTTON SOIL**

To be used at locations where soil is clay type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is to be considered submerged in nature.

f) **SOFT DISINTEGRATED ROCK**

To be used at locations where decomposed or fissured rock gravel, kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations. In case of fissured rock locations, where water table is met at 1.5 metre or more below ground level wet fissured rock foundations shall be adopted. If after soil investigation, water level is encountered at less than 1.5 metre below ground level, a separate foundation design shall be developed.

g) **HARD ROCK**

The locations where chiseling, drilling and blasting is required for excavation hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces. For quoting prices of hard rock foundations rock level shall be assumed at 1.5 metres below the ground level due to change in rock level, no extra payment shall be payable on account of increase in concrete volume, excavation volume and weight of reinforcement, also no recovery shall be made, if the actual volume of concrete, excavations and weight of reinforcement are less than that quoted in Schedule of Prices. However, for design purpose, rock level shall be considered at ground level and no over burden soil weight shall be considered for resisting the uplift.

h) **SANDY SOIL**

Soil with negligible cohesion because of it's low clay content (0-10%).

In addition to the above, depending on the site conditions other types of foundation shall also be provided by the contractor suitable for:

- a) Intermediate conditions under the above classifications to effect economy: or
- b) For locations where special foundations (Well type or piles) are necessitated.

The proposal for these types of foundations shall be submitted by the contractor based on the detailed soil investigation and approval for the same shall be obtained from the Employer.

Note: In all the cases, the water level shall be measured with respect to the tower centre line.

- 2.24.3.4 The relevant characteristics of the various types of soils are given in sub section-I of this specification .It shall be the responsibility of the Contractor to draw the attention and obtain approval of the Employer for the departures necessitated in these design data, should he find it necessary based on his inspection of the site conditions, results of trial pits etc.

2.24.4 FORCES FOR DESIGN OF FOUNDATIONS

- 2.24.4.1 The following forces/loads transmitted to foundation by superstructure due to the action of wind, conductor tension, temperature, earthquake etc. acting thereon shall be considered in the design of foundation:

- a) Maximum Tension/Uplift Force
- b) Maximum Compression Force/Down Thrust.
- c) Maximum horizontal shears/side thrusts in longitudinal and transverse directions.
- d) Additional forces due to eccentricities in the foundation system(if any)

2.24.5 FACTOR OF SAFETY

- 2.24.5.1 For structural design of various component of foundation, load factors shall be considered as per IS: 456

2.24.6 STABILITY OF FOUNDATION

- 2.24.6.1 The foundation shall be designed to withstand the most critical combinations of forces specified in Clause 2.24.4.1 multiplied by relevant factors of safety. The stability of foundation, in general, shall be checked for the following aspects.

- (a) Stability against Uplift
- (b) Stability against Bearing Pressure of Soil
- (c) Stability against Side Thrust
- (d) Stability against Overturning
- (e) Stability against Sliding

- 2.24.6.2 The types of soil resistance to be considered for balancing the various imposed forces by the superstructure on the foundation shall be considered as under:

(a) RESISTANCE AGAINST UPLIFT FORCES

The uplift force shall be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth on the foundation pad with the sides of the pyramidal cone of earth at an angle equal to the angle of internal friction of the soil with vertical. The weight of concrete including reinforcement shall also be considered for resisting the uplift. In case the frustum of earth pyramid of two legs superimposes each other, the earth frustum shall be assumed truncated by a vertical plane passing through the centre line of the tower base. The angle of internal friction and density of various types of soils and properties of concrete are given in sub- section I of the Specification.

(b) RESISTANCE AGAINST COMPRESSION FORCE/DOWN THRUST

The total compression force/down thrust load including additional effective weight of concrete/R.C.C. and weight of embedded steel part shall be resisted by bearing pressure of the soil assumed to be acting on the total contact soil area under the footing. The ultimate bearing pressure for various types of soils enroute the 400 kV line is given in sub- section-I.

(c) RESISTANCE AGAINST THE SIDE THRUST

The horizontal shears/side thrusts shall be assumed to be resisted by the passive pressure of soil around the footing. The passive resistance of the soil shall be calculated as per Rankine's formula. In case, complete side thrust is not balanced by available passive resistance of soil,

unbalanced part of the side thrusts shall be balanced by bearing pressure of soil under the footing.

2.24.7 STRUCTURAL DESIGN OF SPECIAL TOWER FOUNDATION

2.24.7.1 Isolated identical footings shall be provided for each leg of the tower.

2.24.7.2 Depending on soil conditions and loading, the foundation of tower shall be one of the following types:

- (a) SLAB TYPE R.C.C. ISOLATED FOOTING
- (b) UNDER CUT TYPE ISOLATED R.C.C. FOOTING (For soft rock)

2.24.7.3 SEISMIC FORCES

Design of foundations for towers against seismic forces shall conform to IS: 1893 (Part-I) 2002 (latest edition). The basic seismic co-efficient are given in Sub-section I. The important factor to be considered in the calculation of seismic forces shall be 1.5 and other factors shall be as per above code. In the event of award of contract, detailed supporting design calculations regarding adequacy and safety of foundations against seismic forces shall be furnished by the contractor.

2.24.7.4 All foundations shall be designed so as to satisfy and meet the following requirements:-

- (a) The chimney of the foundation shall at least be 300 mm square providing a minimum clear concrete cover of not less than 100 mm over any part of the stub angle in case of dry foundations and at least 450 mm square with minimum clear concrete cover of not less than 150 mm over any part of the stub angle in case of wet, partially submerged and fully submerged foundations.
- (b) The chimney top shall extend 275 mm (minimum) above ground level and coping shall be upto 75 mm below the joint between the bottom bracing and the leg members.
- (c) In all foundations, a lean concrete sub-base having a thickness of 75 mm and of size equal to 75 mm more than the R.C.C. footing on all sides shall be provided under structural concrete. The lean concrete shall be of grade M-10 (1:3:6) conforming to IS: 456. The lean concrete sub-base provided under the footing shall not be considered in the structural calculations.
- (d) The embedded end of the stub angle shall have a 100 mm thick clear concrete cover upto the top of the lean concrete sub-base in the case of dry foundations and a 150 mm thick clear concrete cover in the case of wet, partially submerged and fully submerged foundations.
- (e) The stub shall extend upto the bottom of foundation having a clear concrete cover as specified in para(d) above.
- (f) The depth of foundation below ground level shall not be less than 3.0 m. However the minimum depth may increase in case of special towers as per design.
- (g) The joints between the tower stubs and the superstructure bracing members shall be 300 mm above ground level.
- (h) The chimney shall be designed for combined action of axial force and net bending moment. The maximum compression/tension alongwith both the horizontal shears shall be considered in the design of chimney. The adequacy of chimney section shall be checked as per above and necessary reinforcement in chimney section shall be checked as per above and necessary reinforcement in chimney shall be provided as per design requirements (the stub shall not be considered as reinforcement). The design shall be carried out in accordance with IS:456. Wherever reinforcement is provided in foundations, the clear concrete cover to reinforcement shall not be less than 50 mm.

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- (j) The centroidal axis of the stub shall coincide with the axis of the chimney and pass through the centre of the footing base. The design of the foundation shall take into account the additional forces resulting from eccentricity introduced due to non-compliance of above requirements.

2.24.7.5 The slab type isolated R.C.C. foundations for other than normal towers (to be furnished by the contractor) shall also satisfy and meet the following requirements:

- (a) The structural design of foundations shall be strictly in accordance with IS: 456 and other relevant I.S. Codes.
- (b) The design of R.C.C. foundations shall be carried out by limit state method in accordance with IS: 456 using load factors as given in the above code.
- (c) The minimum thickness of footing slab for foundations shall not be less than 250 mm in case of dry locations and 300 mm in case of wet locations.
- (d) The minimum thickness of footing slab at the edges shall not be less than 150 mm as specified in IS: 456.
- (e) In case of stepped foundations, the reinforcement at top face of each step shall be separately provided. The reinforcement from one step to another step at top face of the footings shall not be permitted.

2.24.7.6 In the case of rock foundations, the holes in the rock shall be made in an approved manner so as to eliminate the possibility of cracking of rock. The concrete block shall be secured in the rock with the help of adequate number of anchor bolts of appropriate diameter grouted with a cement mortar containing suitable non-shrinkage admixture.

2.25 FABRICATION

- 2.25.1 The fabrication of towers shall be in accordance with the provisions made in the following sub-clauses:
 - 2.25.1.1 Except where hereinafter modified, details of fabrication shall conform to the relevant clause of IS: 802 (Part II)
 - 2.25.1.2 All parts of the towers shall be cut to correct lengths and fabricated in accordance with the shop drawings. Welding of two or more pieces to obtain the length of member specified will not be allowed. Members shall be straight to the permissible tolerances or better when required to ensure proper fit before being laid off or worked and after galvanising. Contractor shall furnish the shop drawings in standard format to the employer.
 - 2.25.1.3 Normally butt splices shall be used. The components constituting the joint shall have a total strength greater than the heavier of the members connected. Lap splices may be used for connecting members of unequal sizes. The inside angle of lap splice shall be grinded at the heel to fit the fillet of the outside angle. All splices shall develop full strength of the members connected through bolts. Butt as well as lap splices shall be made above and as close to the main panel points as possible.
 - 2.25.1.4 Joints shall be so designed and detailed as to avoid eccentricity as far as possible. However, where the connections are such that the elimination of gusset plates would result into eccentric joints, gusset plates and spacer plates may be used in conformity with modern practices. The thickness of gusset plates shall not be less than 6 mm. Where a gusset plate is required to transmit stress, its thickness shall not be less than the thickness of the thickest connected bracing members.
 - 2.25.1.5 The uses of fillers in the connections shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary to avoid the use of fillers. Each diagonal shall be in one piece without splices or centre gusset and it shall be connected at the point of intersection by one or more bolts.
 - 2.25.1.6 The tower members shall be accurately fabricated to bolt together easily at site without any undue strain on them or the bolts.

- 2.25.1.7 No angle member shall have the two leg flanges brought together by closing the angle.
- 2.25.1.8 All parts of the towers shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets or depressions are likely to hold water.
- 2.25.1.9 All similar parts shall be made strictly interchangeable. No rough edges shall be permitted anywhere throughout the work.

2.25.2 OPERATING IN FABRICATION

2.25.2.1 STRAIGHTENING

Straightening shall be so done that it does not injure the material. Hammering shall not be permitted for straightening/or flattening of members. Sharp bends shall be a cause for rejection.

2.25.2.2 CUTTING

The cut surfaces shall be clean, smooth, reasonably square and free from any distortion.

2.25.2.3 BENDING

Mild steel angle sections upto 75x75 mm (thickness upto and including 6 mm) shall be bent cold upto and including bend angles of 10 Deg. Angles above 75x75 mm (thickness upto and including 6mm) and upto and including 100x100mm (thickness upto 8 mm) may also be bent cold upto bend angles of 5 Deg. All other angle sections and bend angles not covered above shall not be bent. All plates upto 12 mm thickness shall be worked cold upto a maximum bend angle of 15 Deg.. Hot bending shall be employed for greater bend angles and thicker plates. All hot bend material shall be air-cooled. The bends shall be of even profile and free from any surface damages. Bends on all high tensile steel section shall be done hot.

2.25.2.4 DRILLING AND PUNCHING

Holes in the members shall either be drilled or punched with a jig and shall not be formed by flame cutting process. Drilling or reaming to enlarge holes shall not be permitted. All burs left by punching or drilling shall be completely removed. Punching may be adopted for M.S. sections with thickness upto 16 mm. For thicker sections, drilling shall be done. The holes near the bend line of a bent member on both sides of bend line should be punched/drilled after bending and relative position of these holes shall be maintained with the use of proper templates/jigs and fixtures. When the tower members are in position, the holes shall be truly opposite to each other.

2.26 FASTENERS AND JOINTS

- 2.26.1 It shall be ensured that the fasteners provide positive attachment at all times and under the conditions when the tower structures are subjected to vibrating loads. All tower members shall be joined together with Bolts and nuts. The redundant members of first two (2) panels from ground level shall be connected with Anti-theft bolts and nuts along with spring washers whereas the balance joints shall be connected with hexagonal bolts and nuts. All hexagonal bolts and nuts shall conform to IS-12427. They shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight. Anti-theft bolts and nuts shall have round tapered heads with hexagonal shear nuts. They shall conform to IS 12427 and IS 1367 for property class 5.6/5 except for dimensions which shall be as per enclosed drawing no. SE/400 kV Purchase/017.

2.26.2 BOLTS

- 2.26.2.1 All bolts and nuts shall be galvanised and shall have hexagonal head being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.
- 2.26.2.2 The bolt shall be of 16mm dia/24mm dia and of property class 5.6 as specified in IS:1367 (Part-3) and matching nut of property class as specified in IS:1367 (Part-6).

- 2.26.2.3 Bolts up to M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 310 MPa minimum as per IS: 12427. Bolts should be provided with washer face in accordance with IS: 1363 Part-I to ensure proper bearing.
- 2.26.2.4 To ensure uniformity of galvanising, bolts and nuts should be galvanised by high temperature hot-dip galvanising, at a minimum temperature of 530 deg. C. The temperature should be recorded continuously in the form of a continuous chart. The galvanised coating should be uniform and its value should be between 50 micron to 115 micron to be checked on random sampling basis, on the threaded portion as well.
- 2.26.2.5 Nuts should be double chamfered as per the requirements of IS:1363 Part-3. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4mm oversize on effective diameter for size upto M16.
- 2.26.2.6 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.
- 2.26.2.7 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further, it shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and more than 8mm when fully tightened. All nuts shall fit and tight to the point where the shank of the bolt connects to the head.
- 2.26.2.8 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24mm bolt.
- 2.26.2.9 The successful Bidder shall furnish after proto assembly test of the respective type of towers bolt schedules giving details of members connected, the nut and the washer and the length of shank and the threaded portion of bolts and sizes of holes and any other special details of this nature.

2.26.3 HOLES FOR BOLTING

Holes shall be cylindrical. Oval or lobed forms of holes shall not be permitted. The diameter of the holes shall be equal to the diameter of the bolt plus 1.5 mm. Holes shall be perpendicular to the plates of angles. The accuracy of the location of holes shall be such that for any group of members when assembled the holes shall admit the bolts at right angle to the plane of connection.

2.26.4 SPACING OF BOLT AND EDGE DISTANCES

The minimum spacing of bolts and edge distances shall be as given below:

Bolt diameter (mm)	Hole diameter (mm)	Minimum bolt spacing (mm)	Minimum edge Hole centre to rolled or sawn edge (mm)	Distance of Hole centre to sheared or flame cut edge (mm)
16	17.5	40	20	23
20	21.5	48	25	28

However, maximum possible edge security shall be used for single holes of larger section.

2.26.5 LOCKING DEVICES

Electro-galvanised spring washers of type B of thickness indicated below corresponding to bolt diameter shall be provided for insertion under all nuts

Bolt Diameter (mm)	Thickness of spring washers (mm)
16	3.5
20	4.0

2.26.6 To obviate bending stress in bolts or to reduce the same to a minimum, no bolts shall connect aggregate thickness of more than three times the bolt diameter and also the number carrying stress to be connected by a single bolt shall not generally exceed three(excluding gusset and packing plates).

2.26.7 The gap between the ends of two connected members in a butt shall not be more than 6 mm and less than 4 mm.

2.26.8 TOLERANCES

2.26.8.1 Fabrication tolerances in general shall conform to IS: 7215 unless otherwise specified hereunder:

2.26.8.2 The maximum allowable differences in diameter of the holes on the two sides of the plate shall be 0.8 mm i.e., the allowable taper in a punched hole shall not exceed 0.8 mm on diameter.

2.26.8.3 Tolerance cumulative and between consecutive holes shall be within ± 1.6 mm.

2.26.8.4 Tolerance on gauge distance shall be within ± 0.5 mm.

2.27 ERECTION MARK

2.27.1 Each individual tower member shall carry a code number conforming to the component number given to it in the fabrication drawings. The code number of approved sizes shall be punched on the member before galvanisation and shall be legible after galvanisation. The letter SA/DA (Tangent Tower), SB/DB (small angle tension tower), SC/DC (Medium angle tension tower), SD/DD (Large angle/Dead-End tension tower) and SCT/DCT (Transposition tower) indicating the different types of towers, shall precede the code number in case of towers.

2.28 CHECK ASSEMBLY OF TOWERS

2.28.1 Before proceeding with the bulk fabrication of any type of tower, the Contractor shall fabricate and assemble in his works for inspection by the Employer or his authorised representative, one tower of each type as finally approved by the Employer for checking the fabrication accuracy and workmanship. The check assembly shall be in a horizontal position. Proto assembly made on ground in horizontal position shall be adequately supported to prevent distortion and overstressing of members to ensure proper fit and shall be accomplished without extra - ordinary efforts to align bolt holes or to force pieces into position. For the check assembly, bolts and nuts shall be not more than finger tight.

2.29 GALVANISATION

2.29.1 Fully galvanised towers shall be supplied .Hot dip Galvanisation of tower members shall conform to IS: 2926 and IS: 4759 and that of fasteners to IS: 5358. Spring washers shall be electro galvanised with zinc coating Fenz 25 as per IS: 1573. The galvanisation shall be done after all the fabrication work is completed except that the nuts may be tapped or re-run after galvanisation. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and shall be capable of developing full strength of the bolts. Excess zinc shall not remain in threads, in holes, at member ends in connection areas.

2.29.2 All galvanised material shall withstand tests as per IS: 2633.

2.29.3 The stub shall be hot dip galvanised.

2.29.4 The finished materials shall be dipped into the solution of dichromate after galvanising or treated with approved inhibitor (the details of which shall be given in the Bid) for protection against white rust formation during sea transportation.

2.30 STUB TEMPLATES

Stub setting templates shall be designed, fabricated and arranged by the contractor at his own cost at least one set of each type of stub setting template for double circuit towers with or without extensions. Stub templates for standard towers and towers with extensions upto 9m shall be of adjustable type. The stub setting templates shall be galvanised. Suitable quantity of stub setting templates shall be deployed by the contractor for construction of the line.

However, if employer feels that more number of templates are required for timely completion of the line, the contractor shall have to deploy the same without any extra cost to employer. One set of each type of stub setting template for double circuit towers, as applicable shall be supplied to the employer, on completion of the project at no extra cost to employer.

2.31 DRAWINGS AND BILL OF MATERIALS

2.31.1 The contractor shall furnish the following designs and drawing as and when required after placement of the order.

- i) Fully dimensioned drawing for each standard type of tower complete with cross arms showing sizes of all steel sections, fittings, bolts, attachments etc and clearance diagrams.
- ii) Dimensioned drawings for extensions with sizes of steel sections employed.
- iii) Dimensioned drawings for stubs.
- iv) Dimensioned drawings for stub setting templates.
- v) Dimensioned drawings for anti-climbing device.
- vi) Loading diagram for all towers under different working conditions inclusive of relevant factors of safety.
- vii) Stress diagrams for all towers inclusive of 3-metre, 6- metre and 9-metre tower extensions and cross-arms.
- viii) Tabulations of stresses under different design assumption, permissible stresses for various members employed in the towers, extensions and cross-arms complete with the following information.
 - Members reference for identification on stress-diagrams.
 - Individual loads, inclusive of factors of safety due to transverse, longitudinal vertical, torsional load etc. Under normal and broken wire conditions.
 - Aggregate loads compressive and tensile with factors of safety, based on loadings specified under different conditions.
 - Measured unsupported lengths.
 - Effective unsupported lengths.
 - Appropriate radii of gyration.
 - Sizes of members proposed.
 - Slenderness ratios.
 - Permissible crippling stresses.
 - Gross areas of sections.
 - Permissible crippling loads.
 - No. of size of bolts provided.
 - Net area of sections.
 - Permissible tensile loads.
 - Aggregate cross-sectional areas of bolts.
 - Shearing stress on bolts.
 - Aggregate stress on bolts.
 - Calculated weight of each members.
- ix) Dimensioned drawings for foundations for each type of tower-3-metre, 6-metre and 9-metre extensions with detailed design computations shall also be provided in soft copy. Drawings shall show all details of keying rods, cleat angles etc., to be provided for concrete foundations.
- x) For foundations of each type of towers the drawings shall indicate the following information :

- a) Dimensions of excavation per leg.
- b) Volume of concrete.
- xi) The capacity charts for all types of towers to be used for smaller angles and longer spans shall be furnished alongwith the Bid.

2.31.2 The contractor shall furnish to the Employer for approval the various contract drawings, bills of materials etc. as called for in the various clauses of this specification. These shall include, but shall not be limited to the following:

a) **SHOP DRAWINGS**

Shop drawings shall list in a space above the title, the part number and required quantity of each member detailed on the drawing. Members may be detailed separately or in place in any assembly.

b) **ERECTION DRAWINGS**

Erection drawings shall be furnished for each type of tower and extension and shall show assembly diagram of structures clearly indicating the position of each member and the quantity and size of bolts for each joint.

c) **BILL OF MATERIALS**

A complete bill of material for each type of tower shall be submitted with the erection drawings indicating each part number, required quantities for one tower section of member length, calculated weight and relevant design drawing reference

d) **BOLTS, NUTS AND WASHER SCHEDULE**

Bolts, nuts and Washers schedules shall list the number of bolts and washers required per tower alongwith the sizes and lengths of bolts and number, type and size of washers. The shank length and length of threaded portion of various types of bolts shall be indicated in drawing/table.

2.32 PACKING

2.32.1 The material shall be boxed or bundled for transport in the following manner:

2.32.2 Angles shall be packed in bundles securely wrapped four times around at each end and at every metre with No.9 gauge galvanised steel wire with ends twisted tightly.

2.32.3 Cleat angles, brackets, fillet plates and similar small loose pieces shall be nested and bolted together in multiples, and securely wired together through holes, wrapped round at least four times with No.9 gauge galvanised steel wire and ends twisted tightly. Gross weight of each bundle shall not exceed approximately 70 kg.

2.32.4 The correct number of bolts, nuts and washers to be packed in heavy gunny bags accurately tagged in accordance with the contents and a number of bags packed in a solid box of 22 mm, thick lumber with panelled ends to be securely nailed and further reinforced with 22 mm x 18 gauge iron band stretched entirely around the battons with ends overlapping at least 150 mm. Gross Weight of each box shall not exceed approximately 70 kg.

The packing shall be carried out with caution to protect the material from moisture, salt or any impurities which may cause rust or harmful effects.

The packages shall be new and sufficiently sturdy in construction to withstand normal service incident to shipping and field handling.

2.33 MARKING OF PACKINGS

Each bundle or package shall have the following marks:

- 2.33.1 The name and designation of the consignee (to be furnished by the Employer).
- 2.33.2 The relevant marks and number of tower members, or reference number of bolts, nuts and small components like gusset, various attachments, etc for easy identification.

The marking shall be stenciled in indelible ink on the top members in the bundles of tower steel and on wooden boxes or gunny bags containing smaller components.

Detailed despatch instruction shall be asked for by the Contractor from the Employer at least 4 weeks ahead of the scheduled date of despatch.

All packages shall be marked with the standard packing mark as desired by the Employer.

2.34 PLACE OF MANUFACTURE AND MANPOWER

- 2.34.1 The Bidder must have established steel fabrication facilities in his works or at the works of his Associates. The galvanising bath/plant & equipment available for fabrication, testing facilities available in their works and other institution which they intend to make use of and shall not be changed without the approval of the Employer. The Bidder shall also submit the details of manpower available with his Organisation indicating clearly the number of personnel engaged in the design, fabrication of supporting structures and for erection/construction of the transmission lines. The Bidder shall give a brief profile of the Organisation(s).

2.35 AVIATION REQUIREMENTS

- 2.35.1 Visual aids shall be provided on the transmission line and transmission line structures of height 45 M and above to give warning to flying aircraft about the presence of transmission line and transmission line supports in compliance to the requirement of IS:5613 (part-3/sec.I) 1989 (amendment No.1, July 1994). According to this Employer shall have to comply with the following:

- 2.35.1.1
 - i) The transmission lines and transmission line structures of height 45 m and above shall be notified to the Directorate of Flight Safety (DFS), Air Headquarters (Air HQ), New Delhi.
 - ii) For construction of any transmission line/ structure or a portion thereof, falling within a radius of 20 km around the Defence aerodromes and air to firing ranges provisions of the Aircraft Act 1934, Section 9A as amplified by the associated Gazette Notification SO 988 Part II, Section 3, Sub section (ii) dated 1988-03-26 shall be complied with. Towards this, a No Objection Certificate (NOC) shall be obtained from the concerned aerodrome authorities.
 - iii) Within a radius of 10 km around aerodromes and air to ground firing ranges, all transmission lines and structures of height 45 metres or more shall be provided with day and night visual aids.
 - iv) In all other areas, outside a radius of 10 km, from aerodromes, only those portions of transmission lines and structures of any height identified to pose a hazard to aircraft by the Directorate of Flight Safety shall be provided with day visual aids.

2.35.1.2 DESCRIPTION OF VISUAL AIDS

DAY MARKING

- i) **Line markers:** Coloured globules of 600 mm diameter made of reinforced fiber glass or any other suitable material, weighing 5 kg (approx.), with suitable clamping arrangement and drainage holes shall be installed on earth wire(s) in such a manner that the top of the marker is not below the level of the earth wire. Up to 400 metre span,

one globule shall be provided in the middle of the span on the highest earth wire. In case of double earth wire, the globule may be provided on any one of them. For span greater than 400 metres, one additional globule may be provided for every additional 200 metres span or part thereof. Half orange and half white coloured globule shall be used.

- ii) **Structure Marking:** The structure portion excluding cross arms above 45 m height shall be painted in alternative bands of international orange and white colours. The bands shall be perpendicular to the vertical axis and the top and bottom bands shall be orange. There shall be an odd number of bands. The maximum height of each band shall be 5M.

Night Marking

Medium and low intensity obstacle lights on a complex obstacle such as towers supporting overhead wires should have a night time intensity as per ICAO requirements in International Standards recommended practices. The light on top of the structure should flash at the rate of 20 sequences per minute.

- 2.35.2 The contractor shall arrange required data and documents and will assist in preparation /completion of the case to be submitted to the appropriate aviation authorities for obtaining the No Objection Certificate and shall also extend all help in getting the NOC.

VISUAL AIDS (TO BE PROVIDED)

(A) Day Markings:

a) Painting of Tower

The portion of the towers (excluding cross arms) above 45m height shall be painted over the etched surface in contrasting bands of deep orange or red and snow white as per site requirement. The band shall be horizontal and minimum three bands shall be provided. The minimum width of the colour band shall be one meter and not more than 5 mtrs. Following procedures shall be adopted for painting of towers.

(i) Surface Preparation

The etching of galvanized surface of erected tower members with wash primer is to be done as per IS: 1477 (part-I) to enhance the adhesion of subsequently applied paint coating. Before applying primer, the tower surface is to be cleaned and it should be free from dust, moisture or any foreign substances. One coat of wash primer is to be applied on the galvanised surface and after this second coat of zincchromate primer to be applied after 6 hours, but not later than 48 hours. The primer to be used shall conform to IS:2074 (with latest amendment).

(ii) Final Painting

Two coats of international deep orange or red and snow white paint (deep orange or red band at the top) at alternate interval (bands) as explained above are to be applied. The painting of towers shall generally conform to relevant provisions in IS: 1477 (Part -II). The synthetic enamel paints to be used for painting shall be in accordance with IS: 2932 (with latest amendment).

b) Line / Span Markers

Sphere type span marker of 600 mm diameter shall be provided on the earth wire. The sphere shall be divided into two parts and one half shall be painted in orange and one half in white. Up to 400 metre span, one globule shall be provided in the middle of the span on the highest earth wire. In case of double earth wire, the globule may be provided on any one of them. For span greater than 400 metres, one additional globule may be provided for every additional 200 metres span or part thereof. The design of the markers and their fixing arrangement should be such that they can withstand the wind pressure and shall not induce excessive amount of vibrational strain on earth wire. Appropriate clamping device of cast aluminium alloy are to be provided for clamping. All bolts & nuts are made from stainless steel. The spheres are hollow

and UV protected against fading of colour and weathering. Detail of this arrangement shall be submitted by the Contractor along with Bid.

(B) Night Markers (Obstruction lights)

The scope of night markers covers the design, manufacture, testing at manufacturer's work, if any, supply, delivery, erection, testing and commissioning of medium intensity and low intensity lights along with storage battery & solar panel, control panel, cables, clamps other accessories etc. as per the provision of IS-5613 (Part-II/ Section-1), 1989, amendment No. 1, July, 94 regarding night & day visual aids for denoting transmission line structures as per the requirement of Directorate of Flight Safety.

The detail of each component of medium intensity, low intensity lights & associated accessories to be provided on the towers shall be as per the technical specifications given in the preceding clauses and IS/ICAO, International Standards recommended practices.

One set of Aviation Lights shall consist of one medium intensity light & two/four (as applicable) low intensity lights along with all accessories such as solar panel, control panel, batteries, cables etc.

The low & medium intensity lights, required for each tower shall be operated through a suitable size of common battery bank, solar panel as per requirement of operating voltage & load current of the type of lamps being offered. The lamps shall conform to the ICAO requirement/ relevant BS and shall have weather protection of minimum IP-55 class. The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T. live line, but in no case it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 hrs., the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. Performance certificate of the lamps to be offered shall be furnished by the Contractor.

(i) Medium Intensity Light

Medium Intensity light shall be provided on the top of the tower. The medium light should have night time intensity as per ICAO requirements in International Standards Recommended Practices. The light on top of the structure should flash at the rate of 20 sequences per minute. The effective intensity during night time for the medium flashing light shall be 1600 CD. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc. The light should meet ICAO specification & acceptable to the Civil Aviation authorities. Acceptability of the light from Civil Aviation Authority, if required, shall be the duty of the contractor. The lights should have test reports from the recognized Government labs for the following:

- i. Between 2400-2500 Candela (Cd)/Lux.
- ii. 360 degree round uniform visibility.
- iii. Vertical angle min. 3 degree.

(ii) Low Intensity Lights

Two/ four (as applicable) nos. of low intensity lights are required to be put on each of the towers. Placement drawing for the same shall be submitted by the Contractor. The light shall be stationary lamp with minimum effective intensity of 10 CD of red light. The low intensity lamp shall not generate any R.F. which can interfere with the PLCC signals.

(iii) Storage Battery

Storage Battery required for the above purpose shall be sealed maintenance free, valve regulated lead acid and suitable for mounting on the top of the transmission line towers. Contractor shall offer the most optimum capacity of the Battery Bank at 120 hour discharge rate (considering 80% percentage usage) matching with the load requirement of the type of lamps being offered including any power loss in the associated cables. The battery sizing shall conform to JISC 8707/ relevant Indian Standard or any other internationally recognized standard. The battery shall be hermetically sealed, explosion proof and self-resealing type and free from orientation constraints. The working temperature ranges shall be minimum 0 degree

centigrade and maximum 50 degree centigrade. Performance certificate of the offered batteries shall be submitted by the Contractor.

The battery box suitable for mounting on 400kV power transmission tower shall be robust construction suitable to accommodate desired number of SOLAR BATTERIES with proper clearance between the batteries. The sides and the top of the battery box shall be made from MS sheets not less than 14 SWG thicknesses duly mounted on MS angle frame. The bottom of the battery box shall have suitably designed of MS structure to freely hold the total weight of the batteries. The batteries should be placed on insulated base with proper drainage holes. Lifting lugs shall be provided. Dust and vermin proof lockable doors shall be provided for safety and easy access to the batteries for the maintenance. The battery box should incorporate the design for proper ventilation system in order to prevent a gas concentration inside the box. The ventilation opening shall be protected against rain/ splash water and dust. The inside of the battery box shall be lined with insulating polyurethane plating & exterior painting with weather proof polyurethane paint. The cable entry into the battery box shall be through suitable cable glands.

(iv) Solar Modules

Solar module required for the system shall be suitable for mounting on the transmission line towers and shall be designed for high performance, maximum reliability and minimum maintenance and shall be suitably installed on the tower. The solar modules shall be IP 55 grade protection class. These should be highly resistant to water, abrasion, nail, impact and other environmental factors. These should be placed on the tower at a most optimum angle so as to harness the maximum solar energy and facilitate self cleaning and shall conform to relevant Indian/ International Standards. Module mounting frames shall be weather proof suitable for mounting on tall towers. Details of mounting frames shall be furnished by the Contractor. Junction box shall be provided with weather proof hinged lid with provision for cable glands entry and protections grade of class IP-55. The Contractor shall submit the basis of selecting the numbers of solar modules.

The provision for design, supply & erection of mounting arrangements for photovoltaic modules on the transmission towers in a suitable manner to harness maximum solar energy shall be in the scope of the Contractor. Provision for design, supply & erection of resting platform for the erection of battery bank in a closed enclosure with safety arrangement on the transmission towers shall also be in the scope of the Contractor. The design and load consideration for safety of towers due to additional platform shall be kept in view while designing, selecting the above.

(v) Control Panels.

Control panels shall consist of solar charge controller, flasher unit, sensor, isolator, MCB, Voltmeter, Ammeter and other control gears. Panel enclosure shall be fabricated out of 14 SWG CRCA sheet and thoroughly treated and painted. Suitable neoprene rubber gasket and pad locking device shall be provided and the protection class shall be of IP-55 class. The Solar charge controller shall be most efficient and preferably fully solid state. It shall be provided with protection to load against increase in temperature, surge, automatic low voltage, automatic disconnection, reconnection during high inrush current and normalcy respectively.

The flash regulator shall be provided for regulating light flashing. The same shall be completely solid state and provided with flash rate set points. The protection against overload current shall also be provided. Necessary sensor/ timer shall be provided in the system to "switch on" the light automatically in the evening and poor visibility period and switch off the same during day time and normal visibility period.

(vi) Cable, Cable Glands, Conduits and Accessories

The cable to be supplied and erected shall be of multi strands copper conductor, weather proof, PVC insulated, PVC sheathed, armoured 1.1 kV grade. The same shall conform to IS: 1554. All the cable accessories such as thimble, glands etc. shall be in the scope of supply and erection of the Contractor. Supply and erection of all the PVC conduits and accessories shall be in the scope of the contractor. All the conduit and accessories shall be as per the relevant IS or ISI brand. The inter-connection cable/conduit will be clamped in a secured manner with

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the tower members and any interconnection should be made only inside the environmentally protected junction box.

All the installation on the tower shall be securely and earthed with the tower body by using copper braided wire. The cost of the earthing deemed to be included in the cost

(vii) Type Test

The items/equipments should have already been type tested. However, the type test certificates will be reviewed before pre-despatch inspection.

CHAPTER - 3**CHECK SURVEY, ERECTION, TESTING AND COMMISSIONING**

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CHAPTER - 3**CHECK SURVEY, ERECTION, TESTING AND COMMISSIONING****3.1 SCOPE**

- 3.1.1 This Chapter covers check survey, erection, testing and commissioning of the transmission line and also taking delivery, handling and transportation of towers and tower accessories and other line material from the Employer's stores by the Contractor and distribution to the respective work sites.
- 3.1.2 The erection work shall also include the cost of labour, all tools and plants including tension stringing equipment and all other incidental expenses in connection with the check survey, erection, testing and commissioning of the lines.

3.2 SPECIFIC TECHNICAL REQUIREMENTS

- 3.2.1 The specific technical requirements for erection, testing and commissioning of the line and the particulars of the line, completion programme, etc. are specified in Sub Section-I of this Specification.

3.3 STANDARDS

- 3.3.1 Except where otherwise specified or implied, the erection, testing and commissioning of line shall conform to the provision of IS: 5613(Part-3/Section 2) (as amended up-to-date).
- 3.3.2 The Indian Standard Specifications mentioned below shall be applicable to the materials and processes used in executing the work:

1	IS 383	Course and Fine Aggregates from Natural Sources for Concrete.
2	IS 1200	IS 1200 Method of Measurement of Building and Civil engineering Works Part - I Earthwork.
3	IS 456	Code of Practice for Plain and Reinforcement Concrete.
4	IS 2502	Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement.
5	IS 3043	Code of Practice for Earthing.
6	IS 3764	Safety Code for Excavation Work.
7	IS 4081	Safety Code of Blasting and Related Drilling Operation.
8	IS 4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.
9	IS:1080	Codes of Practice for Design and Construction of Simple Spread Foundations.
10	IS: 1498	Classification and Identification of Soils for General Engineering Purposes.
11	IS:1892	Code of Practice for Subsurface Investigation for Foundation.
12	IS: 1904	Code of Practice for Design and Construction of Foundation in Soils : General Requirements.
13	IS: 2131	Method of Standard Penetration Test for Soils
14	IS: 2132	Code of Practice for Thin Walled Tube Sampling of Soils.
15	IS: 2720	Method of Test for Soils (Relevant Parts)
16	IS: 2809	Glossary of Terms and Symbols Relating to Soil Engineering.
17	IS: 2911	Code of Practice for Design and Construction of Pile Foundations (Relevant Parts)
18	IS: 3025	Methods of Sampling and Testing (Physical and Chemical) for Water

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		Used in Industry.
19	IS: 4078	Code of Practice for Indexing and Storage of Drill Cores.
20	IS: 4434	Code of Practice for In-situ Vane Shear Test for Soils
21	IS: 4453	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.
22	IS: 4464	Code of Practice for Presentation of Drilling Information and Core Description in Foundation Investigation
23	IS: 4968	Method for Subsurface Sounding for Soils, Dynamic Method Using Cone and Bentonite Slurry.
24	IS: 5313	Guide for Core Drilling Observations
25	IS: 6403	Code of Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.
26	IS: 6926	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.
27	IS: 6935	Method of Determination of Water Level in a Bore Hole.
28	IS: 7422	Symbols and Abbreviations for Use in Geological Maps, Sections and Subsurface Exploratory Logs (Relevant Parts)
29	IS: 8009	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations Subjected to Symmetrical Vertical Loads)
30	IS: 8764	Method for Determination of Point Load Strength Index of Rocks.
31	IS: 9143	Method for Determination of Unconfined Compressive Strength of Rock Materials.
32	IS: 9179	Method of Preparation of Rock Specimen for Laboratory Testing.
33	IS: 9259	Specification for Liquid Limit Apparatus
34	IS: 9640	Specification for Split Spoon Sampler.
35	IS: 10050	Method of Determination of Slake Durability Index of Rocks
36	IS: 11315	Description of Discontinuities in Rock Mass Core Recovery and Rock Quality.

3.4 MATERIAL HANDLING AND ACCOUNTING

- 3.4.1 The contractor shall be responsible for safe transportation of, ground -wire, insulators, etc. The contractor shall also be responsible for taking delivery of materials from Carrier Stores for which LR shall be handed over by the consignee. The contractor shall also be responsible for the material supplied by NIGAM. The contractor shall be responsible for proper distribution of the conductor and ground -wire drums so that the numbers and lengths of cut pieces are minimum.
- 3.4.2 No separate charges shall be paid for head loading of materials and tools and tackles. The Bidders shall inspect the line routes before submitting their Bids.

3.5 GENERAL STORAGE OF MATERIAL

- 3.5.1 The cement required for the construction of foundation will be procured by the contractor in bulk from the standard manufacturer approved by the employer. The Contractor shall store cement in suitable weather proof, properly ventilated buildings with dry floors so as to prevent deterioration.
- 3.5.2 The Contractor shall stack the fabricated steel members in separate piles member-wise and tower wise. These shall be stacked clear of the ground with their heels upwards in order to avoid entrapping of water between the angle sections. The reinforcement bars shall also be stored in separate piles in a suitable manner to minimise corrosion.

Other line materials shall be stocked properly with a view of ease of handling, issue, accounting minimum exposure to inclement weather etc.

- 3.5.3 The Contractor shall store the aggregates on hard, smooth and clean surfaces so that there is no possibility of intrusion of any foreign materials. Aggregates of different grades shall be stored in piles which shall be spaced well apart to prevent their intermixing.

Open space, out of land available with RVPN for storage of line material, would be given at one point/place free of cost to the contractor. However, the responsibility for watch and ward of the material shall be of the contractor.

3.6 RIGHT-OF-WAY, CUTTING OF TREES ETC.

- 3.6.1 The Employer will arrange the right-of-way for the land required for tower foundation, tower erection and stringing. Any avoidable or deliberate damage done to standing crop or private property by the Contractor's labour shall be the Contractor's responsibility.
- 3.6.2 Any land required by the Contractor temporarily for dumping of the construction material and consequent damage to crops, etc. shall be the responsibility of the Contractor. The Employer shall not be responsible for arranging access roads/right-of-way for transport of material from road side to work sites. If the Contractor has to adopt any such arrangements he may do so with the consent of the property employers and any compensation in that respect will be his responsibility. The Contractor shall take all reasonable steps for preventing damage to crops during execution of the work.
- 3.6.3 Clearing of obstructions falling in the right-of-way as per IS: 5613 and lopping or trimming of the portion of the trees falling within the minimum electrical clearance zone shall be the responsibility of the contractor. However, compensation shall be payable as per Clause No.1.10.4

3.7 ROADS, RIVER, KHUD/NALLAH, POWER AND TELECOMMUNICATION LINE AND RAILWAY CROSSINGS.

- 3.7.1 The crossings of roads, rivers, khuds/nallahs, power and tele-communication line, and railway tracks falling in the line route shall be carried out with the types of structures and at angles as indicated in the approved profile sheets and tower schedules, ensuring that the minimum clearances at maximum temperature in still wind condition, after taking the effect of conductor creep and slack caused by the broken conductor in the adjoining span are not less than the relevant specified clearances.
- 3.7.2 The crossings of railway tracks, tele-communication lines and erection of lines in the vicinity of aerodromes shall, in addition, meet the requirements of the regulations/code listed below:
- i) Regulations for Electrical crossing of Railway Tracks issued by the Ministry of Railways.
 - ii) Code of Practice for Crossings between Power and Tele-communication Lines-1974 (As amended upto date).
 - iii) Requirements for routing of overhead lines in the vicinity of aerodromes laid down by the Director General of Civil Aviation, Govt. of India.

3.8 CROSSING OF PUBLIC UTILITIES

- 3.8.1 The Contractor shall be responsible for giving requisite notice to the appropriate authorities and intimate them the date and time when he proposed to carry out erection of the conductors and ground wires along or across power lines or tele- communication lines, public roads, waterways, railways etc. Lowering of the conductors, ground -wires etc. of the existing power lines and its restringing and taking all necessary precautions to avoid damage to the existing lines will be the responsibility of the Contractor. Any guying, temporary reinforcement required for the existing structures will also be the responsibility of the Contractor.

3.8.2 Where other authorities or public undertakings affected, deem it necessary for the protection of their employees, property, public, or for the assistance of traffic to provide flagmen or watchmen, the cost of such provision shall be borne by the Contractors.

3.8.3 Where it is necessary to provide scaffolding over roads, power lines or tele-communication lines, this shall be carried out by the Contractor at such times as may be convenient to the requisite authority and such work shall be deemed to be covered in the rates. Flagmen and approved types of danger or warning notices shall be provided by the Contractor to ensure safety of the public. The time taken to effect the crossing shall be kept to be minimum.

3.9 ERECTION TOOLS AND PLANTS

3.9.1 The Contractor shall provide at his own expenses all necessary erection tools, plants and manpower required for erection and commissioning of line.

3.10 EXECUTION OF WORKS

3.10.1 Setting out and survey.

3.10.1.1 The Bidders shall quote for detailed survey as incorporated in chapter 1 of Sub Section - II in schedule B.2(Survey).(sub-section -IV)

The Contractor shall assume full responsibility for the following works.

3.10.1.2 CHECK SURVEY

The Contractor shall perform all necessary check survey work which consists of determination, checking and lay out the accurate center line and elevation of all the reference points, based on the key map and plan and profile drawings furnished. Furthermore, the Contractor shall check the minimum clearance of conductor crossing the existing highway, railway, major waterway, tele-communication lines, power lines etc. Trimming of tree branches, bushes etc. during check survey will be responsibility of the Contractor. In case of the transmission line passing over hilly and mountainous country, unequal legs of towers are required, the Contractor shall perform the diagonal profile and plan drawings for the selection of individual leg extension.

3.10.2.3 STAKING

The Contractor shall stake the locations of the towers as shown on the plan and profile drawings. Three stakes will be provided on the centre line of the transmission line. One stake at the centre of the proposed tower location and the other two reference stakes will be located on the centre line of transmission lines, at desired distance ahead and back respectively of the centre stake. The top of the centre stake will be driven to an elevation to be known as the working point from which the line and grade of the tower shall be erected. During staking of the locations of towers, if the site of any tower as spotted in the plan and profile drawings is not suitable by reason of topographical geological or any other affecting conditions, the contractor shall be required to recommend the proper locations of towers to the Employer for consideration. The Contractor shall carry on the work in accordance with the Employer's decision.

The check survey and staking work shall be performed by the qualified and experienced personnel and supervised by the qualified surveyor. Not less than 30 days prior to the commencement of the work, the Contractor shall submit the qualifications of surveyor(s), work programme and list of surveying equipment for the approval of the Engineer incharge. One copy of the corrected key map, plan and profile drawings and structure list including diagonal profile and plan drawings of hill side towers, if any, shall be submitted to the Engineer incharge with final survey data.

3.10.2.4 The further erection activities shall only be started after the tower schedules and profile finally approved by the Engineer incharge and received by the Contractor.

- 3.10.2.5 The Contractor shall be responsible for correct setting out of towers as per the finally approved profile sheets and tower schedules. If towers, after erection, are found to be out of approved alignment, the Contractor shall dismantle and re-erect them correctly at his own cost without extension in time.

3.11 ELECTRIC POWER FOR CONSTRUCTION PURPOSES

- 3.11.1 The Contractor shall make all necessary arrangements and provide all necessary electric power for construction purposes at his own cost. In case the power is available with the Employer, the same shall be supplied at the prevailing per unit rate.

3.12 EXCAVATION

3.12.1 EXCAVATION FOR TOWER SITES, DRAINAGE AND LINE CLEARANCE

- 3.12.1.1 This item covers excavation for leveling around the individual tower footings, drainage, line clearance etc. but excludes the excavation for tower footings. The excavations for tower sites, drainage and line clearance shall be made to the approved dimensions and shall be finished according to the specified lines and grades. Where the Employer considers it necessary, adequate drainage shall be provided around tower footings, except as otherwise provided in this specification, excavated materials shall be used for grading as directed, around the site up to 50 m lead from which the materials are excavated. The requirement of excavation for tower sites, drainage and line clearance at any location and the amount of excavation required shall be optional with the Employer.

- 3.12.1.2 Measurements for payment for excavation for tower sites, line clearance and drainage will be made to the most practicable lines and grades as approved by the Employer. Payment for such excavation, including the associated grading shall be made at the unit rate per cubic metre quoted in the Schedule of Prices.

3.12.2 EXCAVATION FOR FOOTINGS

- 3.12.2.1 Except as hereinafter provided, all excavations for footings shall be made to the lines and grades of the foundation designs approved by the Employer. The excavation wall shall be vertical and the pit dimensions shall be such as to allow a clearance of 150 mm on all sides from the foundation pad. The contractor should ensure clearance of 150 mm from the foundation pad for quality work. However payments shall be restricted to guaranteed volumes or actual whichever is less as per unit rates. Any excavation done beyond the lines of the foundation shall be in contractor's account. Any sand, mud, silt or other undesirable materials which may have accumulated in the excavated pits shall be removed by contractor at no extra cost before placing concrete. The contractor at no extra charges shall dispose of all surplus soil.

3.12.2.2 CLASSIFICATION OF SOIL

The materials to be excavated shall be classified as follows unless otherwise specified.

S.No	Name of Soil Encountered	Type of Foundation
1	In good soil (silty sand mixed with clay content of 10-15%)	Normal Dry (ND)
2	Sub soil water met at 1.5 m below GL in good soil or where surface water stand for long period with water penetration not exceeding 1.0m below GL; e.g. paddy fields.	Wet
3	Top layer of normal dry soil extends up to 85% of the depth followed by fissured rock without presence of water.	Dry Fissured Rock (DFR)
4	In good soil where sub soil water encountered between 0.75 m and 1.5 m depth from GL.	Partially Submerged (PS)
5	In good soil where sub soil water encountered within 0.75 m depth from GL.	Fully Submerged (FS)

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6	Hard Rock is encountered at 1.5 m or less below GL	Hard Rock (HR)
7	Black Cotton Soil is encountered at 1.5 m or less below GL and extends upto full depth.	Wet Back Cotton Soil (WBC)
8	Soil with clay content not exceeding 10%.	Sandy soil
9	Sub soil water met at 1.5 m below GL in dry fissured rock or where surface water stand for long period with water penetration not exceeding 1.0m below GL; e.g. paddy fields.	Wet Fissured Rock (WFR)

3.12.2.3 Where tower foundations fall on composite soil nature, classification shall be according to the type of soil which is preponderant in the footing for each tower and the rate for the same shall apply for the composite foundations.

3.12.2.4 In case of locations where dewatering is required during excavation or concreting , any of the following methods shall be employed :

i) MANUAL:

Dewatering done by men with the help of buckets etc. (The unit rate shall be quoted per man hour).

ii) MECHANICAL:

Dewatering done by men using hand-pumps (the unit rate inclusive of the charges of the operating persons shall be quoted per pump hour).

iii) POWER DRIVEN PUMPING:

Dewatering done with the help of engine or electrical motor driven pump with a power input of net less 5 H.P. (The unit rate inclusive of the charges of operating staff shall be quoted per pump hour).

iv) No dewatering charges shall be paid by the Employer for any dewatering during the process of excavation. No extra charges shall be admissible for the removal of any excavated earth falling in a pit in which excavation has once been completed. However, dewatering charges shall be paid during concreting only.

3.12.2.5 Where rock is encountered, the holes for tower footings shall preferably be drilled, but where blasting is to be resorted to as an economy measure, it shall be done in accordance with the relevant Indian Standard and with utmost care to minimise the use of concrete for filling up the blasted areas. All necessary precautions for handling and use of blasting materials shall be taken as per the requirements of the relevant safety code (A).

Only the persons having certificate for blasting issued by the competent authority shall be deployed for carrying out the blasting. The explosive for blasting, if required, shall be arranged by the contractor. In case unnecessary large quantities is excavated/blasted resulting in the use of large volumes of concrete, payment for concrete shall be limited to the guaranteed volume and the cost of any concrete in excess of that shall be borne by the Contractor. In case drilling is done, the stubs may be shortened suitably as approved by the Employer.

3.12.2.6 Payment for excavations for tower footings shall be made at the unit rate per cu.m. for the appropriate type of soil. The unit prices shall include the cost of necessary labour and material for all timbering, shoring and spreading the excess material evenly around the site. If during the progress of excavation or after the completion of excavation, any alterations in the dimensions of excavation actually made become necessary compensation therefore shall be determined as follows:

i) Where additional excavation is called for on account of alteration in the dimensions of excavation for a footing as a result of the use of improper methods of excavation or means for supporting excavation or providing inadequate protection of the excavation against weathering or delay between excavating the pit and placing of the concrete by

the Contractor, the cost of all additional reinforcement, cement, concrete, back filling and compacting shall be borne by the Contractor.

- ii) Where additional excavation is called for due to change of the type of footing on account of different soil conditions, payment shall be made in accordance with the provision existing in this specification.

3.12.3 EXCAVATION OF BORROWED EARTH FOR BACKFILL

- 3.12.3.1 This item covers excavation of borrowed earth required for backfill at the borrow areas designated by the Employer. The Contractor shall strip the borrow area of all unsuitable material as may be necessary to obtain the required quantities of borrowed materials. The surfaces of borrow areas shall be left in reasonably even condition.
- 3.12.3.2. Measurement for payment for excavation at borrow areas for backfill will be made only for the quantities required for the backfill and the quantities which are excavated with the approval of the Employer to strip the borrow areas of the unsuitable material.
- 3.12.3.3 The Bidders shall quote unit rate per cu.m. for excavation of borrowed earth for backfill in the Schedule of Prices. This rate shall include the cost of transporting borrowed earth to and placing the same at the points of final use.

3.12.4 FORM WORK

- 3.12.4.1 Only steel or laminated water proof ply form work shall conform to the shape, lines and dimensions of the footings as per the design drawings. All details of the form work, placing, typing, etc. shall be subject to the approval of the Engineer-in-charge. The Contractor shall submit drawing showing details of the form construction. The form work shall be adequate to withstand the pressure of freshly placed concrete or other loads imposed, without failure, movement or deflection of the component parts. Form work shall be sufficiently tight to prevent the loss of liquid from the concrete.

The inner surface coming in contact with concrete shall be smooth and free from projections. All rubbish particularly chipping, shavings, dust and traces of concrete, if any, shall be removed from the interior of the form work before the concrete is placed. The surface in contact with the concrete shall be wetted and sprayed with fine sand or treated with an approved composition to prevent absorption of water from the concrete. Such composition shall be kept out of contact with reinforcement and shall be non-staining and non-injurious to concrete.

3.13 CONSTRUCTION OF TOWER FOOTINGS

3.13.1 GENERAL

- 3.13.1.1 The type of footings to be constructed at each tower site shall be based on the soil characteristics indicated on the route profile sheets and as determined by the Engineer during the progress of the work. The Employer reserves the right to change the type of footings at the locations where conditions during the progress of work indicate the use of a different type of footing.
- 3.13.1.2 Each tower shall have four identical footings each of which shall have steel stub angle embedded in reinforced concrete. The footings for each tower in straight section of the line shall be placed so that the longitudinal axis of the tower cross-arms will be in a plane perpendicular to the transverse of the line. Unless otherwise directed by the Employer, the footings for each angle tower shall be placed in a manner so that the tower cross-arms lie in a plane bisecting the interior angle formed by the inter- section of the traverses of adjacent sections of the line.

3.13.2 SETTING OF STUBS

- 3.13.2.1 The stubs shall be set correctly at the exact locations and alignment and precisely at correct levels. Stubs shall be set in the presence of authorised representative of the Employer available at site for which adequate advance intimation shall be given to the Employer by the

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Contractor. This shall not however, absolve the Contractor of his responsibility for correctness of stub setting and for the correct erection of towers.

3.13.2.2 Foundation shall be constructed in accordance with the approved drawings. Cement and Steel for reinforced concrete, plain concrete based on theoretical calculations plus the specified wastage, shall be arranged by the Contractor.

3.13.2.3 The stubs shall be set with their tops above the ground level as per approved design and given a coping without making plinth.

3.14 CONCRETE

3.14.1 The Contractor shall inform the Employer or his authorised representatives sufficiently in advance about the programme of concreting the locations.

3.14.2 Concrete used for casting foundations shall conform to specifications appended separately to this specification (Specification for concreting of foundations). The proportion of cement, sand and aggregate in the mix are subject to change to obtain strength of M 20 and M-10 grade concrete conforming to IS-456. The Contractor shall arrange testing of concrete samples at recognised Test Laboratory for various mix at his own cost before commencement and during concreting or whenever the quality and grading of material is changed in the presence of the Employer's representative(s).

3.14.3 The weight of concrete to be considered for design of foundations is given as under :

WEIGHT OF CONCRETE

Type of concrete	weight of dry region kn/m3 (KG/m3)	weight in presence of sub-soil water kn/m3 (KG/m3)
Concrete	21.96(2240)	12.16(1240)
Reinforced	23.54(2400)	13.73(1400)

3.14.4 a) The Ordinary Portland cement used in concrete shall conform to IS: 8112/12269.

b) The Pozzolana Portland cement used in concrete shall conform to IS: 1489. The curing time of Pozzolana Portland cement will be decided at the time of execution of the contract.

c) Make of cement shall be of major cement producers.

3.14.5 Concrete aggregates shall conform to IS:383.

3.14.6 The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalies, organic materials or other deleterious substances. Potable water is generally preferred.

3.15 REINFORCEMENT

3.15.1 The bending and fixing of bars for concrete reinforcement shall be in accordance with IS-2502 (as amended upto date), reinforcement shall be cold twisted deformed bars conforming to IS: 1786.

3.15.2 All reinforcement shall be clean and free from loose mill scales, dust loose rust and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of drawings and specifications.

3.16 BACKFILLING

3.16.1 Back filling shall normally be done with the excavated soil unless it consists of large boulders/stones in which case the boulders shall be broken to a maximum size of 80 mm. The backfill material shall be clean and free from vegetation pieces of timber and other undesirable materials. Backfill shall not be dropped directly upon or against any foundation or facility where there is danger of displacement or damage.

Backfill shall be placed in horizontal layers not to exceed 200 mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 92% of maximum density corresponding to optimum moisture content as determined by the relevant Indian standard codes. Trucks or heavy equipment for depositing or compacting the backfill shall not be used within 1.5 metre of facilities which may be damaged by their weight or operation. Methods of compaction shall be subject to approval of the Engineer-in-charge.

- 3.16.2 After back filling, 150mm high earthen embankment (Bund) along the sides of excavation pits shall be made and sufficient water poured in the back-filled pits so that standing water remains above the back-filled earth for atleast 24 hours. All surplus soil including residual sand, stone and concrete waste lying around if any shall be stacked within the tower base.
- 3.16.3 While back filling of footings the pad shall be covered with about 300 mm layer of fine material before any coarse material is deposited. Care shall be taken to avoid damage to the concrete during back-filling and compaction of soil.
- 3.16.4 All top soil shall be placed at the surface in the case of towers located on cultivated land.
- 3.16.5 The cost of back-filling and compaction shall be included in the unit prices quoted for stub setting in the Schedule of Prices.
- 3.16.6 Where the excavated material is not considered to be suitable by the Employer for use as back-fill, borrowed earth shall be used as back- fill for which the provision of Clause 3.13.3 of this Specification shall be applicable.

3.17 PROTECTION OF TOWER FOOTINGS

- 3.17.1 The work shall include all necessary stone revetment concreting and earth-filling above ground level. Special measures for protection of foundations shall be taken in respect of locations close to/in nallah, river beds etc. by providing suitable crate of galvanised wire netting and meshing packed with boulders. The top seal cover of the revetment work shall be done with M-15 concrete (1:2:4 nominal mix.) The Contractor shall furnish recommendations for providing protection at such locations. Where the ground surface is irregular, the foundation shall be finished off in a substantial and permanent way by forming a plinth by side cutting and building a suitable stone revetment or in case of rock foundation by building up with cement concrete as desired by the Employer. The number of retaining walls and breast walls en-route transmission line shall be intimated by the Contractor for obtaining the decision of the Employer before taking up erection.

In case of hilly/sloppy terrain, the benching area should be leveled properly. The area around tower shall have proper slope for drainage of rain water.

- 3.17.2 The unit rate of protection of the tower footing shall be quoted in the Schedule of Prices and shall include the pointing (flush and ruled type) using 1:3 (cement sand mortar) on masonry of retaining/breast walls.

3.18 GROUNDING

- 3.18.1 The installations of earthing sets shall be in accordance with relevant standard specifications. The galvanised steel pipe sets shall be installed in the ground near the towers and connected to the lower legs by means of galvanised steel flat as shown in Drg.No. SE/400 kV Purchase/011 where tower footing resistance exceeds that specified in Sub-Section I of this Specification. The desired earthing resistance shall be obtained by installing additional pipe earthing sets. The distance between two electrodes in such a case shall preferably be not less than twice the length of electrode.
- 3.18.2 At locations, where it is not possible to obtain the desired footing resistance by the means mentioned in Clause 3.18.1 installation of counterpoise earthing shall be provided. Four galvanised steel stranded conductors shall be radiated from tower as shown in Drg. No. SE/400 kV Purchase/012.

- 3.18.3 Where a tower stands on rock, efforts shall be made to obtain a good ground by carrying a length of galvanised steel flat from the tower legs to earthing pipe driven in damp soil at the shortest possible distance from the tower. The connecting flat shall be buried in a groove cut in the rock surface and adequately protected from damage.
- 3.18.4 The Contractor shall measure and record the resistance of each tower to earth after erection and before installing the earth-wire and submit the same to the Employer.

3.19 HANDLING AND TRANSPORTATION OF STEEL

- 3.19.1 All galvanised tower steel including stub angles, shall be handled and transported to work site by the Contractor with care to avoid bending to members and damage to galvanised surfaces.

3.20 TOWER ERECTION

- 3.20.1 Towers shall be erected member by member assembly or any other standard method without overstressing any member on foundations at least after 14 days of casting but a gap of 28 days shall be preferred. The tower shall be erected in the best workmanlike manner.
- 3.20.2 The Contractor shall be entirely responsible for correct erection for all towers as per the approved drawings and their correct setting on the alignment finally approved by the Employer. The towers must be truly vertical after erection, the permitted tolerance in verticality being 1 in 360 of the tower height. No straining will be permitted to make the towers vertical.
- 3.20.3 A reasonable amount of drifting as permissible in IS:5613 (Part-3/Section 2) shall be allowed in assembling, but reaming for correction of mismatched holes due to shop errors will not be permitted. If any shop errors are discovered, the Contractor shall notify the Employer, who will decide whether the errors may be corrected in the field or members returned to tower fabricator for correction or replacement. All galvanised surfaces damaged as a result of correction shall be made good as directed by the Employer.
- 3.20.4 All errors and omissions in erections of towers shall be corrected by the Contractor at no additional cost to the Employer. Any tower damaged during erection due to incomplete bolting, improper guying or any other reasons, shall be repaired/replaced by the Contractor as directed by the Employer.

3.20.5 ASSEMBLY

- 3.20.5.1 The method followed for the erection of towers, shall ensure the points mentioned below:

- i) Straining of the members shall not be permitted for bringing them into position. It may, however, be necessary to match hole positions at joints and to facilitate this, Tommy bars not more than 450 mm long may be used.
- ii) Before starting erection of an upper section, the lower section shall be completely traced and all bolts provided in accordance with approved drawings.
- iii) All plan diagonals relevant to a section of tower shall be placed in position before assembly of upper section is taken up.
- iv) The bolt positions in assembled towers shall be as per IS:5613(Part -3)/Section 2).
- v) Tower shall be fitted with number plate, danger plate, phase plates, Circuit plates and anti-climbing devices as described.
- vi) All the blank holes, if any left, after complete erection of the tower, are to be filled up by bolts and nuts of correct size.

3.21 TIGHTENING, PUNCHING AND WELDING OF BOLTS AND NUTS

- 3.21.1 All nuts shall be tightened properly using correct size spanners. Before tightening, it will be ensured that filler washers and plates are placed in relevant gaps between members, bolts of proper size and length are inserted and one spring washer shall be placed under each nut, and in case of step bolts, spring washers have been placed under the outer nuts. The tightening

shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at three positions on the diameter to ensure that the nuts are not loosened in course of time. If during tightening a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced.

- 3.21.2 All the bolts projected outside the nuts shall be welded with the nuts at two diametrically opposite places. The length of each welding shall be atleast 10 mm. The welding shall be provided from ground level upto bottom cross arm level. Except for accessories bolts punching and tack welding of all the tower bolts shall be completed before starting stringing work. After welding cold galvanised paint (Zinc rich paint) having atleast 90% (percent)zinc contents shall be applied to the welded portion. Atleast two coats of the paint shall be applied. No extra payment shall be given for painting work.

3.22 TOWER ACCESSORIES

- 3.22.1 Each tower shall be fitted with number plate, circuit plates, danger plate and phase plates.
- 3.22.2 Anti-climbing device shall be provided on all towers.
- 3.22.3 Bird-guards shall be provided on double circuit suspension towers.

3.23 INSULATOR HOISTING

- 3.23.1 The insulators, string fittings and insulator string assembly drawings shall be supplied by Contractor. The numbers of insulator units required per string are given in chapter-5 of this specification. Single suspension insulator strings shall be used on tangent towers and tension strings on all tension and dead end towers.
- 3.23.2 Damaged insulators and fittings, if any, shall not be used in the assemblies. All insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case any oils shall be used for the purpose. For checking the soundness of insulator IR measurement using 5 kV megger shall be carried out on 5% insulators. Before hoisting, the components of the insulator string shall be checked for any damage, crack and missing of security clips etc. Corona control rings shall be fitted in a approved manner. The yoke arrangements shall be horizontal for tension and longitudinal for suspension strings. Torque wrench shall be used for fixing different components, like suspension clamp for conductor and ground wire, etc. whenever recommended by our site engineers.
- 3.23.3 The installation of string assemblies shall also include the installation of armour rod sets at suspension locations.
- 3.23.4 The compression dead ends and jumper connection in tension assemblies shall be fixed to conductor in accordance with manufacturer's recommendations which shall be furnished by the Contractor to RVPN.
- 3.23.5 Sacking shall be wrapped over the cross arm members of towers to prevent damage to the galvanised surface during hoisting of string assemblies.
- 3.23.6 Payment for installing insulator assemblies of various types shall be included in the rates quoted in the Schedule of Prices for stringing of conductors.

3.24 HANDLING OF CONDUCTOR AND GROUND WIRE

- 3.24.1 Before commencement of stringing, the Contractor shall submit stringing charts for the conductor and earth-wire for various temperatures corresponding to spans and equivalent spans prepared on the basis of the data given in Sub Section I of this Specification and also on the data obtained from the detailed survey for the approval of the Employer.
- 3.24.2 The Contractor shall be entirely responsible for any damage to the towers or conductors during stringing. A suitable braking device shall be provided to avoid damping, loose running out and kinking of the conductor. While running out the conductors, care shall be taken that the

conductors do not touch and rub against the ground or objects which cause scratch or damage to the strands. The conductors shall be run out of the drums from the top in order to avoid damage due to chafing, immediately after running out, the conductor shall be raised at the supports to the levels of the clamp and placed into the running blocks which shall be of such a design that the seat is semi-circular and larger than the diameter of the conductor ground -wire and it does not slip over or rub against the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

- 3.24.3 The running blocks shall be suspended in a manner to suit the design of the cross-arm. All running blocks, especially those at the tensioning end shall be fitted on the cross arms with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work. Normally, suspension towers shall not be used even for temporary termination. In case small or medium angle towers are used even for temporary terminations, these shall be well guyed and steps be taken by the Contractor to avoid damage. Guying proposal alongwith necessary calculations shall be submitted by the Contractor to Engineer-in- charge for the approval. Proper T&P shall also be made available to the Employer by the Contractor for checking the tensions in the guy wires. The drums shall be provided with a suitable braking device to avoid damages, loss during running out and stringing of the conductor. The conductor shall be continuously observed for loss or broken strands or any other damage. When approaching end of a drum length, atleast three coils shall be left when the stringing operations are to be stopped. These coils are to be removed carefully and if another length is required to be run out, a joint shall be made as per the recommendations of the conductor manufacturers.
- 3.24.4 Repairs to conductors, if necessary, shall be carried out during the running out operations, with repair sleeves. Repairing of conductor surface shall be done only in case of minor damage scuff marks etc. keeping in view both electrical and mechanical safe requirements. The final conductor surface shall be clean smooth and shall be without any projections, sharp points, cuts, abrasions etc.
- 3.24.5 The Contractor shall take adequate steps to prevent clashing of sub-conductors from the process of paying out to the installations of the spacers/spacer dampers. Care shall be taken that both sub-conductor of a bundle are from the same conductor supplier and preferably from the same batch so that creep behavior of the sub-conductor remains identical. During sagging care shall be taken to eliminate differential sag in the sub-conductor as far as possible. However, in no case sag mismatch shall be more than 25 mm.
- 3.24.6 Conductor splices shall be so made that they do not crack or get damaged in the stringing operation. The Contractor shall use only such equipment/methods during conductor stringing which ensures complete compliance in this regard.
- 3.24.7 Derricks and scaffolding shall be used where roads, rivers, channels, tele-communication or overhead power lines, railway lines, fences or walls have to be crossed during stringing operations. It shall be seen that normal services are not interrupted or damage caused to property. Shut-down shall be obtained when working at crossing of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, ground -wire and accessories in the field.
- 3.24.8 Suitable guards/sheaves shall be from top to downwards, i.e. the ground -wire shall be run out first followed by the conductors in successions. Unbalances of loads on towers shall be avoided as far as possible.
- 3.24.9 The proposed 400 kV transmission line may run parallel for certain distance with the existing 400 kV, 220 kV, 132 kV lines etc. which may remain energized during the stringing period. As a result there is a possibility of dangerous voltage build-up due to electromagnetic and electrostatic coupling in the pulling wire conductors and ground -wires, which although comparatively small during normal operations can be severe during switching operation, it shall be the Contractor's responsibility to take adequate safety precautions to protect his employees and other from this potential danger.

- 3.24.10 Proper guying arrangements shall be made by the Contractor during stringing to avoid unbalanced loads on towers.

3.25 STRINGING OF CONDUCTOR AND EARTH -WIRE

- 3.25.1 The stringing of the conductor shall be done by the control tension methods, with the help of tension stringing equipment capable of maintaining a continuous tension. The maximum tension imposed on a conductor during paying out operations shall not normally exceed 50% of the sagging tension except in cases where higher tension is required for clearing obstructions from the ground or maintaining necessary clearance from HT, LT and P&T lines. In such cases, the tension shall not exceed that required for maintaining the sag about twenty percent greater than the sag specified in the sag-tension chart.
- 3.25.2 Controlled stringing method suitable for simultaneous stringing of both conductors shall be used. Both the conductors making one phase bundle shall be pulled in and paid off simultaneously. Both the conductors of the bundle shall be of matched length. After being pulled the conductor/earth-wire shall not be allowed to hang in the stringing blocks for more than 96 hrs. before being pulled to the specified sag.
- 3.25.3 Conductor creep are to be compensated by over tensioning the conductor at a temperature of 26° C lower than the ambient temperature or by using the initial sag and tensions indicated in the sag tables.

3.26 JOINTING

- 3.26.1 All the joints on the conductor and ground -wire shall be of compression type, in accordance with the recommendations of the manufacturer for which all necessary tools and equipment like compressors, dies etc. shall have to be arranged by the Contractor. Each part of the joint shall be cleaned by wire brush to make it free of rust or dirt etc. and shall properly be greased with anti- corrosive compound, if required and as recommended by the supplier before the final compression is done with the compressors.
- 3.26.2 All joints or splices on the conductor and ground -wire shall be made atleast 30 metres away from the structures, No joints or splices shall be made in the spans crossing over main roads, railways and rivers. Not more than one joint per sub-conductors shall be allowed in one span. The compression type fitting used shall be self-centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation, the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After pressing the joint, the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothed.
- 3.26.3 During stringing of conductor, to avoid any damage to the joint, the Contractor shall use a suitable protector with mid span compression joints. In case joints are to be passed over pulley blocks/aerial rollers, the size of the groove of the pulley shall be such that the joint along with protector can be passed over it smoothly. The arrangements to be adopted shall be explained in the Bids.

3.27 SAGGING-IN-OPERATION

- 3.27.1 The tensioning and sagging shall be done in accordance with the approved stringing charts or sag tables. The "Initial" stringing chart shall be used for the conductor and "Final" stringing chart for the earth-wire. The conductors shall be pulled upto the desired sag and left in running block for atleast one hour after which the sag shall be re-checked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductors shall be clamped within 96 hours of sagging in.
- 3.27.2 The sag will be checked in the first and the last span of the section in case of sections upto eight spans and in one intermediate span also for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

- 3.27.3 The running blocks, when suspended from the transmission structure for sagging shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.
- 3.27.4 At sharp vertical downward angles, the sags and tensions shall be checked on both sides of the angles, the conductor and earthwire shall be checked on the running block for equality of tension on both sides. The suspension insulator assemblies shall normally assume vertical positions when the conductor is clamped.
- 3.27.5 Tensioning and sagging operations shall be carried out in calm weather when rapid changes in temperatures are not likely to occur. In areas where calm weather is not prevalent during working season, the Contractor shall recommend the precautions to be taken during final tensioning and sagging of conductor.

3.28 TENSIONING AND SAGGING OF CONDUCTORS AND GROUND-WIRE

- 3.28.1 The tensioning and sagging shall be done in accordance with the approved stringing charts before the conductors and ground -wire are finally attached to the towers through the ground - wire clamps for the ground -wire and insulator strings for the conductor. Dynamometers shall be employed for measuring tension in the conductor and ground-wire. The dynamometers employed shall be periodically checked and calibrated with a standard dynamometer.
- 3.28.2 Provision for ground undulations, errors in stringing and compensation for creep in conductors. This shall be considered at the time of stringing of conductors.
- 3.28.3 No pre-stressing/ over-tensioning of the ground -wire shall be done.
- 3.28.4 The adjustment of sub-conductor sag by means of sag adjustment devices provided in the insulator string shall invariably be not permitted at the time of stringing of the conductors. The sag adjustment plates shall be kept in intermediate position at the time of stringing of the conductor
- 3.28.5 The Contractor shall terminate the line conductors and ground -wires at the dead-end towers on each end of the line. Payment for stringing work shall be made for the actual route length of the line at the unit rates quoted for the stringing of conductors and ground -wires in the Schedule of Prices.

3.29 CLIPPING IN

- 3.29.1 Clipping of the conductors in position shall be done in accordance with the recommendations of the manufacturer. Conductor shall be fitted with the armour rods at suspension point and with vibrations dampers at suspension and tension points.
- 3.29.2 The jumpers at the section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator string shall be used, if so desired by the Employer to restrict the jumper swings to the designed values.
- 3.29.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

3.30 FIXING OF CONDUCTOR AND GROUND -WIRE ACCESSORIES

- 3.30.1 Spacer dampers, rigid spacers and other conductor and ground -wire accessories shall be installed by the Contractor as per the design requirements and respective manufacturer's instruction. Spacer dampers and Rigid spacers shall be fitted within 24 hrs. of the conductor clamping. While installing the conductor and ground -wire accessories proper care shall be taken to ensure that the surfaces are clean and smooth and no damage shall occur to any part of the accessories.
- 3.30.2 The Contractor shall ensure that drain holes, if provided, in the weights of the dampers are open. The spacer/spacer dampers shall be installed at the intervals indicated by the Employer.

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The required number of spacers cars/cycles with metre counters suitable for installing spacer/spacer damper shall be arranged by the Contractor.

- 3.30.3 Rates for installing dampers and spacers shall be included in the rates of stringing of conductor and earthwire.

3.31 REPLACEMENT

If any replacements are to be effected after stringing and tensioning or before handing over leg members and bracing shall not be removed without reducing the tension on the tower with proper guying or releasing the conductor if the replacement of cross arms becomes necessary after stringing, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

3.32 FINAL CHECKING, TESTING AND COMMISSIONING

After completion of the works, final checking of the line shall be done by the contractor to ensure that all the foundation works, tower erection, and stringing have been done strictly according to the specifications and as approved by the Employer. All the works shall be thoroughly inspected keeping in view of the following main points.

- (a) Sufficient backfilled earth is lying over each foundation pit and it is adequately compacted.
- (b) Concreted chimneys and their copings are in good finally shaped conditions.
- (c) All the tower members are correctly used, strictly according to final approved drawings and are free from any defect or damage whatsoever.
- (d) All bolts are properly tightened and punched/and tack welded (as specified).
- (e) The stringing of the conductors and ground -wire has been done as per the approved sag and tension charts and desired clearances are clearly available.
- (f) All conductor and ground -wire accessories are properly installed.
- (g) All other requirements to complete the work like fixing of danger plate, phase plates, number plate, circuit plates, anti- climbing device, bird guard, aviation aids/signal (wherever required) etc. are properly installed.
- (h) Wherever required, it should be ensured that revetment is provided.
- (i) The original tracings of profile, route alignment and tower design, structural drawings, bill of material, shop drawings of all towers are submitted to the Employer for reference and record.
- (j) The insulation of line as a whole is tested by the contractor by providing own equipment, labour etc. to the satisfaction of the Employer.
- (k) The line is tested satisfactorily for commissioning purpose.
- (l) The right of way all along the route of line is clear of all obstruction and meet requirements of Clause No.5.3 of IS:5613(Part-3/Section-2).
- (m) In addition to the tests stipulated in IS:5613(Part-3 /Section 2) the tower footing resistance at the locations decided by the Employer, shall be measured. All arrangements for testing shall be made by the Contractor and the necessary labour, transport and equipment shall be provided by him.
- (n) Any defects found as a result of testing shall be rectified by the contractor forthwith to the satisfaction of the Employer without any extra charges.
- (o) Before taking over of the line by the Employer, the line shall be energized at full working voltage.

3.33 METHOD OF MEASUREMENT:

3.33.1 SURVEY:

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The measurement shall be based on the detailed survey, tower spotting and route profile sheets submitted by the Contractor as specified in technical specification. No kilometeric measurement shall be made at site in respect of survey. The length of the section, as per approved check survey schedule, between two angle/ section towers in which stub-setting of all the towers has been carried-out shall be considered as the length of the line of which the survey has been completed.

3.33.2 EARTHWORK EXCAVATION:

For all earthwork excavation, measurement shall be made at site. Payment for earthwork excavation shall be made as per unit rates quoted/agreed by the bidder, on the basis of actual measurements or the ceiling quantity furnished in the bid whichever is lower and in accordance with the technical specification, irrespective of classification of foundation to be approved by RVPN.

3.33.3 CONCRETING:

For all concreting work, measurement shall be made at site. Payment for concreting work shall be made as per actual measurement or the ceiling quantity furnished in the bid whichever is lower and in accordance with the technical specification.

3.33.4 TOWER ERECTION AND ASSEMBLY:

No measurements are to be taken, but payments shall be made in respect of fully assembled towers including fixing of accessories in accordance with the Technical Specification.

3.33.5 STRINGING OF CONDUCTORS:

Measurement of section length as per approved check survey schedule shall be taken as the length of the line for the purpose of stringing. Payment shall be made on the basis of this section length (and not on the length of the conductor used) and in accordance with the Technical Specification.

3.34 ERECTION SCHEDULE

3.34.1 The transmission line covered under this specification is required to be completed as per the programme given in the Schedule of requirements and completion of line.

3.34.2 The Bidder shall submit erection schedule covering all phases of work starting from the date of award of contract upto the commissioning of the transmission lines, in the form of flow diagrams showing critical path construction schedule of all phases of work simultaneously or in the form of Bar Chart.

3.35 PROGRESS REPORT

3.35.1 Fortnightly progress reports in duplicate shall be regularly submitted to the Chief Engineer (T&C), with a copy to Superintending Engineer (TCC/400 kV Purchase), Executive Engineer (Const.)/ Incharge of works.

3.36 WASTAGE

As the work of Erection & Commissioning of the line is in the scope of the contractor, no wastage, damages, losses etc. shall be allowed for any material. However, for ground wire and ACSR MOOSE conductor an extra allowance @ 0.3% shall be allowed towards sag and jumpering which shall be unaccountable.

The contractor shall make every effort to minimize breakage, losses and wastage of the line materials during erection. However the Contractor shall be permitted an extra consumption of conductor and earth wire up to the limits specified above and shall be permitted to dispose of the scrap, if any, at their end. If the actual length of conductor required for completing the line exceeds the allowed length of conductor (including above specified percentage allowance of 0.3%) then such excess length of conductor shall be supplied by the NIGAM to the contractor at RVPN's purchase cost plus 15%.

The Contractor shall not be required to return to the employer, empty conductor and earth wire drums and shall dispose of the same at his cost.

Any conductor/ earth wire drum which has been opened by the contractor shall not be taken back by employer and the unused conductor/ earth wire in such drums may be treated within the over all limits specified above.

The conductor shall return to the employer all employer supplied material not incorporated in the works, except those permitted by employer as above. Otherwise, the contractor shall pay in respect of such excess material which he is unable to return, at rates corresponding to RVPN's purchase cost plus 15%.

3.37 EXAMINATION OF WORK BEFORE COVERING UP:

No work shall be covered up or put out of view without the approval of the Engineer or the Engineer's representative and the Contractor shall afford full opportunity for the Engineer or the Engineer's representative to examine and measure any work which is about to be covered up or put out of view and to examine foundations before permanent work is placed thereon. The Contractor shall give due notice to the Engineer's representative whenever any such work or foundation is or are ready or about to be ready for examination and the Engineer's representative shall without delay advise the Contractor accordingly, attend for the purpose of examining and measuring such work or of examining such foundations.

3.38 UNCOVERING AND MAKING OPENINGS:

The Contractor shall uncover any part or parts of the works or make openings in or through the same as the Engineer may from time to time direct and shall reinstate and make good such part or parts to the satisfaction of the Engineer. If any such part or parts have been covered up or put out of view, after compliance with the requirement of Clause No. 3.38 above, and are found to be executed in accordance with the contract, the expenses of uncovering, making openings in or through reinstating and making good of the same shall be borne by the Employer, but in all other cases, these costs shall be borne by the Contractor.

3.39 REMOVAL OF IMPROPER WORK AND MATERIALS:

a) The Engineer/Engineer's representative shall, during the progress of the works, have power to order in writing from time to time.

- i) The removal from the site within such time or times as may be specified in the order of any materials, which in their opinion are not in accordance with the contract.
- ii) The substitution of proper and suitable materials and
- iii) The removal and proper re-execution, notwithstanding any previous tests thereof or interim payment therefore, of any work which in respect of materials or workmanship is not in accordance with the contract.

b) In case of default on the part of the Contractor in carrying out such an order, the Employer shall be entitled to employ and pay other persons to carry out the same and all expenses consequent thereon or incidental thereto shall be recoverable from the Contractor by the Employer or may be deducted by the Employer from any amount due or which may become due to the Contractor.

3.40 GENERAL RESPONSIBILITIES OF THE CONTRACTOR:

3.40.1 WORKS EXECUTION:

The Contractor shall, subject to the provision of the contract and with due care and diligence execute and maintain the works and provide all labour, including the supervision thereof, materials, constructional plant and all other things, whether of a temporary or permanent

nature, required in and for such execution and maintenance, so far as the necessity for providing the same is specified in or is reasonably to be inferred from the contract.

3.40.2 WORKS SAFETY:

The Contractor shall take full responsibility for the adequacy, and safety of all site operations and method of construction, provided that the Contractor shall not be responsible, except as may be expressly provided in the contract for the design or specification of the permanent works.

3.40.3 SUPERINTENDENCE BY THE CONTRACTOR:

The Contractor shall give or provide all necessary Superintendence during the execution of the works and as long thereafter as the Engineer may consider necessary for the proper fulfilling of the Contractor's obligations under the contract.

3.40.4 SETTING OUT OF WORKS:

The Contractor shall be responsible for the true and proper setting out of the works in relation to original points, lines and levels of reference given by the Engineer in writing and for the correctness, subject as mentioned above of the position, levels, dimensions, and alignment of all parts of the works and for the provision of all necessary instruments, appliances and labour in connection therewith. If, at any time during the progress of the works, any error shall appear or arise in the position levels, dimensions, or alignment of any part of the works, the Contractor on being required so to do by the Engineer, shall at his own cost, rectify such error to the satisfaction of the Engineer unless such error is based on incorrect data supplied in writing by the Engineer, in which case the expense of rectifying the same shall be borne by the employer. The checking or setting out of or any line or level by the Engineer shall not in any way relieve the Contractor of his responsibility for the correctness thereof and the Contractor shall carefully protect and preserve all bench-marks, sight rails, pegs and such other thing used in the setting out of the works.

3.40.5 CARE OF THE WORKS:

From the date of commencement of the works until the date stated in the certificate of completion for the whole of the works, the Contractor shall take full responsibility for the care thereof. Provided that, if the Engineer shall issue a certificate of completion in respect of any part of the permanent works, the Contractor shall cease to be liable for care of that part of the permanent works from the date stated in the certificate of completion in respect of that part and the responsibility for the care of that part shall pass on to the employer. In case of any damage, loss or injury shall happen to the works, or to any part thereof, from any cause whatsoever, the Contractor shall at his own cost, repair and make good the same so that the completion of the permanent works shall be in good order and in condition and in conformity in every respect with the requirements of the contract.

3.40.6 WATCHING AND LIGHTING:

The Contractor shall in connection with the works provide and maintain at his own cost all lights, guards, fencing and watching when and where necessary or required by the Engineer/Engineer's representative or by any duly constituted authority, for the protection of the works or for the safety and convenience of the public and others.

3.40.7 CONTRACTOR TO KEEP SITE CLEAR:

During the progress of the works, the Contractor shall keep the site free from all unnecessary obstruction and shall dispose off any constructional plant surplus materials, and clear away and remove from the site any wreckage, rubbish or temporary works no longer required.

3.40.8 CLEARANCE OF SITE ON COMPLETION:

On the completion of the works, the Contractor shall clear away and remove from the site all constructional plant, surplus materials, rubbish and temporary works of every kind and leave

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the whole of the site and works clean and in a workman like condition to the satisfaction of the Engineer.

3.40.9 WORK TO BE DONE TO THE SATISFACTION OF ENGINEER/ENGINEER'S REPRESENTATIVE:

Save in-so-far as it is legally or physically impossible, the Contractor shall execute and maintain the works strictly in accordance with the contract to the satisfaction of the Engineer/Engineer's representative and shall comply with and adhere strictly to their instructions and directions on any matter whether mentioned in the contract or not.

3.40.10 WAY LEAVES:

The Contractor shall bear all costs and charges for special or temporary way leaves required by him in connection with access to work sites.

3.40.11 PLANT, TEMPORARY WORKS AND MATERIALS:

All constructional plant, temporary works, and materials provided by the Contractor shall, when brought to the site, be deemed to be exclusively intended for the execution of the works and the Contractor shall not remove the same or any part thereof, except for the purpose of moving it from one part of the site to another.

3.40.12 REMOVAL OF PLANT ETC:

Upon completion of the works, the Contractor shall remove from the site all the said constructional plant, temporary works remaining thereon and any unused material provided for by the Contractor.

3.40.13 EMPLOYER NOT LIABLE FOR DAMAGE TO PLANT ETC:

The Contractor shall note that the employer shall not at any time be liable for the loss of or damage to any of the aforesaid constructional plant, temporary works or materials.

CHAPTER - 4

SPECIAL TOWERS

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CHAPTER-4

SPECIAL TOWERS

4.1 GENERAL

4.1.1 The Special tower shall be used for major river crossing and other long spans of the order of 800 to 1300 metres. The scope of supply of these towers includes survey, foundations, tower erection and stringing shall also form the part of the Bidder's scope. The Bidder shall submit the most economical design for the towers.

4.1.2 For anchoring of major river crossing towers, dead end type towers shall be used. The requirement of dead-end towers shall be deemed as included in the scope of work.

4.2 TECHNICAL REQUIREMENTS

4.2.1 All the requirements for standard towers shall apply for special towers except as given in the following clauses.

4.3 SHIELDING ANGLE

The shielding angle shall not be greater than 10 Deg.

4.4 CLEARANCES

4.4.1 The minimum clearance of lowest point of power conductor from highest flood level in case of navigable rivers for crossing towers shall be obtained from the navigation authority by the Contractor for Employer's approval.

4.4.2 The minimum electrical clearances between live parts and tower body and cross arm member will be same as for normal tower.

4.4.3 The approximate height of foundation on which stubs for river crossing(special)towers are to be set above the highest flood level of the river shall be fixed only after Employer's approval.

4.5 ANGLE OF DEVIATION

The angle of deviation to be considered for special suspension towers is 4 Deg. and all the live metal clearance to be computed considering suspension string as per Drawing No. SE/400 kV Purchase/003.

4.6 FACTOR OF SAFETY

The design of special tower shall be carried out in accordance with the provisions covered in IS-802 (Part-1/Sec-2):1995. However, yield strength of steel used, the estimated loads shall be increased by a factor of 1.10.

4.7 DAMPERS

The contractor will also recommend the number of spacer dampers in case of long spans for satisfactory performance.

4.8 ADDITIONAL STRUCTURAL REQUIREMENT

4.8.1 Minimum of 2 bolts shall be provided for the connection of any members having connected flange width equal to or greater than 90 mm. Also the member carrying computed stresses shall have minimum of 2 bolts. All members placed horizontally or included upto 30 degree shall be designed to withstand independently 150 Kg. load acting downward.

4.8.2 Secondary members shall be so arranged that they are connected at least at one end to members carrying computed stresses.

4.8.3 Minimum thickness for the gussets shall be 2 mm more than the lattice it connects only in case when the lattice is directly connected on the gusset outside the leg members.

CHAPTER-5 INSULATORS

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CHAPTER-5**INSULATORS****5.1 SCOPE**

The scope covers for design, manufacture, engineering, inspection & testing at manufacturer's works before despatch, supply of Disc Insulators (Ball & Socket type) for 400 kV double circuit transmission line. The bidder may quote for disc porcelain/toughened glass or porcelain long or composite long rod insulator.

5.2. STANDARDS

The insulator strings and its components shall conform to the relevant Indian Standards/International standards which shall mean latest revisions, with amendments/changes adopted and published, unless otherwise stated in the specification. The relevant standards shall include the following.

In the event of the supply of insulators conforming to standards other than specified, the Contractor shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the contractor and those specified in this document will be provided by the contractor establishing their equivalence.

IS: 731	Specification for Porcelain insulators for overhead power lines with a nominal voltage greater than 1000 volt.
IS:2486 (Part-1)	Metal fitting of insulator for overhead power lines with a nominal voltage greater than 1000 volt - Specification, General requirements & tests
IS:2486 (Part-2)	Metal fitting of insulator for overhead power lines with a nominal voltage greater than 1000 volt - Specification -Dimensional requirements
IS:2486 (Part-3)	Metal fitting of insulator for overhead power lines with a nominal voltage greater than 1000 volt - Specification - Locking devices
IS:2486 (Part-IV)	Specification for insulator fitting for overhead power lines with a nominal voltage greater than 1000 volt - Tests for locking devices
IS:3188	Characteristics of string insulator units
IS:209	Specification for Zinc
IS:406	Method of Chemical Analysis of Slab Zinc
IS:2071 (Part-I, II, III)	Methods of High Voltage Testing
IS:2629	Recommended Practice for Hot, Dip galvanisation for iron and steel
IS:2633	Testing of Uniformity of Coating of zinc coated articles
IS:3188	Dimensions for Disc Insulators
IS:6745	Determination of weight of zinc coating on zinc coated iron and steel articles
IS:8263	Methods of RIV Test of HV insulators
IS:8269	Method for switching impulse test on HV insulators
IEC:575	Thermal mechanical performance test and mechanical performance test on string insulator units
IEC:507	Salt Fog Pollution voltage withstand test.
IEC:815	Guide for the selection of insulators in respect of polluted conditions.
ASTMC151-93- a	Standard Test Method for Autoclave Expansion of Portland Cement.
ANSIC29-2-1992	American National Standard for Insulators wet process porcelain and toughened glass suspension type.
IEC:383	Test on insulators of ceramic material or glass for over head lines with a nominal voltage greater than 1000 V
IEC:437	Methods of RIV test of HV insulators
IEC:372	Locking devices

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IEC:797	Residual strength of string insulator unit of glass or ceramic material for overhead line after mechanical damage of the dielectric
IEC: 60575	Thermal Mechanical Performance test and mechanical performance test on string insulator units
IEC:60797	Residual Strength of String Insulator Units of Glass or Ceramic Material for Overhead Lines after Mechanical Damage of the Dielectric
IEC:60815	Guide for the selection of insulators in respect of polluted conditions
IEC:60383	Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V
IEC : 60433	Characteristics of string insulator units of the long rod type
IEC 61109	Composite insulators for A.C. Overhead lines with nominal voltage greater than 1000V – Definitions, test methods and acceptance criteria
IEC:60815-3	Selection and dimensioning of high voltage insulators intended for use in polluted conditions: Polymer Insulators for AC systems
IEC 61466-1	Composite string insulator units for overhead lines with a nominal voltage above 1000V : Standard strength classes and end fittings
IEC 61466-2	Composite string insulator units for overhead lines with a nominal voltage above 1000V : Dimensional and electrical characteristics
IEC 60587	Electrical Insulating materials used under severe ambient conditions – Test methods for evaluating resistance to tracking and erosion
IEC 62217	Polymeric insulators for indoor and outdoor use with nominal voltage greater than 1000V- General definitions, tests, methods and acceptance criteria.

5.3 PRINCIPAL TECHNICAL PARAMETERS:-

5.3.1 Disc Insulator:

The characteristics of the Disc insulator unit shall be as follows:

- | | | |
|------|------------------------|---|
| i) | Nominal system voltage | 11 kV, 3 Phase 50 Hz effectively earthed. |
| ii) | Rated voltage | 12 kV (rms) |
| iii) | Type | Conventional Ball & Socket type. |
| iv) | Colour | Brown |
| v) | Surface | Glazed |

5.3.2 STRING ARRANGEMENTS

Insulator and insulator strings shall be suitable for use in the following system /voltage:

- | | | |
|-----|------------------------|--|
| i) | Power System | 400 kV, 3 Phase 50 Hz effectively earthed. |
| ii) | Highest system voltage | 420 kV (rms) |

INSULATOR AND INSULATOR STRINGS PARTICULARS (required for 400 kV twin Moose conductor)

S. No.	Particulars	Single Suspension I-String	Double Suspension I-String	Single Suspension Pilot String	Single Tension String.	Double Tension String.
1.	Type of disc	Standard				
2.	E& M Strength of each disc in kN	120	2x120	120	120	2x160
3.	No. of insulator disc per string	1x23	2 x 24	1x23	2 x 24	2 x 23
4.	Size of Disc in mm	280x145 or 255x145	280x145 or 255x145	280x145 or 255x145	280x145 or 255x145	280x170

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S. No.	Particulars	Single Suspension n I-String	Double Suspension I-String	Single Suspension Pilot String	Single Tension String.	Double Tension String.
5.	Size and Designation of pin ball shank (mm)	20	20	20	20	20
6.	Minimum Creepage distance of each disc (mm)	320	320	320	320	330

5.3.3 INSULATOR STRING CHARACTERISTICS

The characteristics of the complete insulator string for 400 kV systems shall be as follows:

1.	Nominal Voltage	kV	400
2.	Maximum system voltage	kV	420
3.	BIL (Impulse)	kV (Peak)	1550
4.	Power frequency withstand voltage (Wet)	kV (rms)	680
5.	Switching surge withstand voltage (Wet)	kV (rms)	1050
6.	Minimum Corona extinction voltage at 50 Hz AC system under dry condition	kV (rms) phase to earth.	320 (Min)
7.	Radio interference voltage at one MHz for phase to earth voltage of 320 KV under dry condition.	Micro Volts	1000 (Max)

5.3.4. Pin and Cap

Pin and Cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric of such design that it will not yield or distort under load conditions.

The pin ball shall move freely in the cap socket but without danger of accidental uncoupling during erection or in position. The design of the disc should be such that stresses due to expansion or contraction in any part of the insulator shall not lead to deterioration.

5.3.5 Security clip

Security clip for use with ball and socket coupling shall be of R-shaped hump type which shall provide positive locking of the coupling as per IS:2486-(Part-III)/IEC : 372. The legs of the security clips shall be spread after installation to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall locking device allow separation of insulator units or fittings.

The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required to pull the security clip into its unlocked position shall not be less than 50N (5 kg) or more than 500N (50 kg).

5.3.6 Ball and Socket Designation

The dimensions of the balls and sockets shall be of 20 mm designation for 120 KN & 160 KN disc insulators in accordance with the standard dimensions stated in IS:2486(Part II)/IEC:120.

5.3.7 Dimensional Tolerance of Disc Insulator

It shall be ensured that the dimensions of the disc insulators are within the limits specified below:-

a)	Diameter of Disc (mm)			
		<u>Standard</u>	<u>Maximum</u>	<u>Minimum</u>
	120 kN Disc	255/280	266/293	244/267

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	160 kN Disc	280	293	267
b)	Ball to ball spacing between discs			
		<u>Standard</u>	<u>Maximum</u>	<u>Minimum</u>
	120 kN Disc	145	149	141
	160 kN Disc	170	175	165

5.3.8 Interchangeability

The disc insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with the hardware fittings of any make conforming to relevant Indian/International Standards.

5.3.9 Corona and RI Performance

All surfaces must be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The metal parts shall be so designed and manufactured that it shall not generate any Radio Interference beyond specified limit and not produce any noise generating corona under the operating conditions.

5.3.10 Maintenance

5.3.10.1 The disc insulators offered shall be suitable for employment of hot line maintenance techniques so that the usual hot line operations can be carried out with ease, speed and safety.

5.3.11 Materials

5.3.11.1 Porcelain

The porcelain used in the manufacture of shells shall be sound, free from defects thoroughly vitrified and smoothly glazed.

5.3.11.2 Glaze

The finished porcelain shall be glazed in brown colour. The glaze shall cover all exposed parts of the insulator and shall have a good lusture, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not crack or chip by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as of the porcelain body throughout the working temperature range.

5.3.11.3 Toughened Glass

The glass used for the shells shall be sound, free from defects such as flaws. Bubbles, inclusions etc. and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

5.3.11.4 Cement

Cement used in the manufacture of the insulator shall not cause 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 care shall be taken to correctly centre and locate individual parts during cementing.

5.3.11.5 Pins and Caps

Pins and Caps shall be made of drop forged steel and malleable cast iron/spheriodal graphite iron/drop forges steel respectively, duly hot dip galvanized and shall not be made by jointing, welding, shrink fitting or any other process from more than one piece of material.

5.3.11.14 Security Clips

Security clips shall be made of good quality stainless steel or phosphor bronze as per IS:1385. 2.5% extra Security clip shall be provided.

5.3.12 Workmanship

- 5.3.12.1 All the material shall be of the latest design and conform to the best modern practices adopted in the extra high voltage field. Suppliers shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for 400 kV Transmission lines and will give continued good service.
- 5.3.12.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.
- 5.3.12.3 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.
- 5.3.12.4 Metal caps shall be free from cracks, seams, shrinks, air holes, burrs and rough edges. All surfaces of the metal parts shall be perfectly smooth with no projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.
- 5.3.12.5 All ferrous parts shall be hot dip galvanized to give a minimum average coating of Zinc equivalent to 600 gm/sq.m. and shall be in accordance with the requirement of IS:2629 and shall satisfy the tests mentioned in IS:2633. The zinc used for galvanized shall be of Grade Zn 99.95 as per IS:209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand atleast six successive dips each lasting for one (1) minute duration under the standard preece test.
- 5.3.12.6 Before ball fittings are galvanized, all die flashing on the shank surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.
- 5.3.12.7 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 is no contact between the shell of one unit and metal of the next adjacent unit. The design of the shell ribs shall be such that the security clip of the insulator can be engaged and disengaged easily with hot stick without damaging the shell ribs.
- 5.3.12.8 Insulator units after assembly shall be concentric and co-axial within limits as permitted by the relevant Indian Standards.

5.4 Technical Description of Porcelain Long Rod Insulators

5.4.1 Details of Long Rod Insulators

- 5.4.1.1 The insulator string shall consist of standard long rod insulators with normal sheds for a three phase, 50 Hz, effectively earthed 400 kV transmission system in a lightly polluted atmosphere. Insulators shall be long rod type with Ball and socket connections.
- 5.4.1.2 Insulators shell have normal sheds/alternate sheds with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-815.
- 5.4.1.3 Electro porcelain long rod insulator shall also be supplied with Intermediate ball pins and intermediate arcing horns.

The price of these items shall be considered as including in the price of long rod insulators.
- 5.4.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string alongwith hardware fittings shall be as follows:

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5.4.1.5 Description of long rod insulator string (equivalent to standard disc insulator)

Sl. No.	Type of string	Size of long rod insulators (mm)	Minimum creepage distance of each unit (mm)	No. of individual units per string	Electro-mechanical strength of insulator disc(KN)	Mechanical strength of insulator string along with hardware fittings (KN)
For 400 kV D/C (Twin Bundle) TL						
1.	Single 'I' suspension	60-75	2415	1 x 3	120	120
2.	Double "I" Suspension string	60-75	2415	2 x 3	120	2X120
3.	Single 'I' suspension pilot	60-75	2415	1 x 3	120	120
4.	Double Tension string.	75-85	2530	2 x 3	160	2 x 160
4.	Single Tension string.	60-75	2415	1x 3	120	120

Note: (i) Bidders may quote for the relevant strings.

(ii) Length of long rod insulator strings shall be matching with the corresponding disc insulator strings.

(iii) The cost of intermediate Ball pin and intermediate arcing horn shall be considered as including in the price of long rod insulators.

5.4.2 Pin and Cap

5.4.2.1 Pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric, of such design that it will not yield or distort under load conditions.

5.4.2.2 The pin ball shall move freely in the cap socket but without danger of accidental uncoupling during erection or in position. The design of the long rod should be such that stresses due to expansion or contraction in any part of the insulator shall not lead to deterioration.

5.4.3 Ball and Socket Designation

The dimensions of the balls and socket shall be of 20 mm designation for 120 & 160 kN for long rod insulators in accordance with the standard dimensions stated in IS 2486-(Part-II)/IEC:120.

5.4.4 Dimensional Tolerance

The tolerance on all dimensions e.g. diameter, length and creepage distance shall be allowed as follows :

$\pm (0.04 d + 1.5)$ mm when $d < 300$ mm.

$\pm (0.025d + 6)$ mm when $d > 300$ mm

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

However, no negative tolerance shall be applicable to creepage distance.

5.4.5 Intermediate Ball Pin Designation

The dimensions of the intermediate ball pin shall be in accordance with the standard dimension stated in IEC:471.

5.4.6 Intermediate Arcing Horn

- 5.4.6.1 For Insulator strings with long rod insulators besides the arcing horn on tower side of hardware fittings, intermediate arcing horns along with fixtures and fasteners shall also be provided.

The total effective arcing distance shall be 3050 mm under nominal dimensions of insulator.

- 5.4.6.2 The spark gap shall be so adjusted to ensure effective operation under actual field coordination.

5.4.7 Inter Changeability

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

5.4.8 Corona and RI Performance

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

5.4.9 Maintenance

- 5.4.9.1 The long rod insulators offered shall be suitable for employment of hot line maintenance techniques so that usual hot line operations can be carried out with ease, speed and safety.

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

5.4.10 Materials

5.4.10.1 Porcelain

The porcelain used in the manufacture of long rods shall be alumina type. It shall be sound, free from defects and thoroughly vitrified and smoothly glazed.

5.4.10.2 Glaze

The finished porcelain shall be glazed in brown colour. The glaze shall cover all exposed parts of the insulator and shall have a good luster, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not be cracked or chipped by aging under the normal service conditions. The glaze shall have the same co-efficient of expansion as of the porcelain body throughout the working temperature range.

5.4.10.3 Insulator Cap

The caps of long rod insulator units shall be of malleable cast iron or other suitable material, duly hot dip galvanised and shall not be made by jointing, welding, shrink fitting or any other process from more than one piece of material. The design of the unit shall be such that stresses due to expansion and contraction of any part of the insulator shall not lead to deterioration.

5.4.10.4 Intermediate Ball Pin

The intermediate ball pin shall be made of drop forged steel, duly hot dip galvanised and shall not be made by jointly welding, shrink filling or any other process from more than one piece of material.

5.4.10.5 Intermediate Arcing horn

Intermediate Arcing horn shall be mild steel tube.

5.4.10.6 Cement

Cement used in the manufacture of the insulator shall not cause 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 care shall be taken to correctly centre and locate individual parts during cementing.

5.4.11 Workmanship

- 5.4.11.1 All the materials shall be of latest design and conform to the best modern practices adopted in the extra high voltage field. Bidders shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for 400 kV transmission lines and will give continued good service.
- 5.4.11.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.
- 5.4.11.3 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.
- 5.4.11.4 Metal caps shall be free from cracks, seams, shrinks, air holes and rough edges. All surfaces of the metal parts shall be perfectly smooth without the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.
- 5.4.11.5 All ferrous parts shall be not dip galvanised to give a minimum average coating of zinc equivalent to 600 gm/sq. mm. and shall be in accordance with the requirement of IS: 2629 and shall satisfy the tests mentioned in IS : 2633. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. the galvanised metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanising shall be carried out only after any machining.
- 5.4.11.6 The design of the insulators shall be such that the porcelain shall not engage with hard metal.
- 5.4.11.7 Insulator units after assembly shall be concentric and co-axial within limits as permitted by the relevant international standard.

5.5 Technical Description of Composite Long Rod Insulators

5.5.1 Details of Composite Long Rod Insulators

The insulators of the strings shall consist of composite long rod insulators for a three phase, 50 Hz, effectively earthed 400kV transmission system. Couplings shall be ball and socket type.

The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactory. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in Appendix-C of IEC-61109.

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

The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string alongwith hardware fittings shall be as follows:

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S.No	Type of String	*Size of Composite Insulator (Core dia x Nominal length) (mm)	Minimum Creepage Distance (mm)	No. of individual Units per String (Nos.)	Electro-Mechanical Strength of Insulator Unit (kN)	Mechanical Strength of Insulator String along with Hardware Fittings (kN)
1.	Double 'I' Suspension	20x3335	13020	2x1	120	2x120
2.	Single Suspension 'Pilot'	20x3335	13020	1x1	120	120
3.	Single 'I' Suspension	20x3335	13020	1x1	120	120
4.	Single Tension	20x3335	13020	1x1	120	120
5.	Double Tension	24x3910	13020	2x1	160	2x160

Note: *The core dia of composite insulators mentioned at column No.3 is for indicative purpose. The bidder shall offer composite long rod insulators of suitable core dia to meet specified E&M and torsion strength requirements. For offered core dia, less than indicated in table above the bidder shall submit documentary evidence of past supplies & satisfactory operation of the same for minimum period of three years. However, the overall string length shall be within the limits specified in the drawing.

5.5.2 Pin and Cap

Pin and cap shall be designed to transmit the mechanical stress and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric of such design that it will not yield or distort under load conditions.

The design shall be such as to permit easy removal of replacement of either insulator units or fittings under the live line conditions.

5.5.3 Ball and Socket Designation

The dimensions of the Ball and Socket shall be of 20 mm designation for 120 kN & 160 kN Insulators in accordance with the standard dimensions stated in IEC:120/ IS:2486 (Part-II).

5.5.4 Dimensional Tolerance of Composite Insulators

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

$\pm (0.04d+1.5)$ mm when $d \leq 300$ mm.

$\pm (0.025d+6)$ mm when $d > 300$ mm.

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

The tolerance in creepage distance shall be based on design dimensions and their tolerances. However, no negative tolerance shall be applicable to creepage distance specified in clause 5.5.1.4.

5.5.5 Interchangeability

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

5.5.6 Corona and RI Performance

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

5.5.7 Maintenance

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

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

5.5.8 Materials

Core

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

Housing & Weathersheds

The FRP rod shall be covered by a sheath of a silicone rubber compound of a thickness of minimum 3mm. The housing & weather sheds should have silicon content of minimum 30% by weight. It should protect the FRP rod against environmental influences, external pollution and humidity. It shall be extruded or directly moulded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique to be followed with detailed procedure and sampling shall be furnished by the Contractor and finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile. The weather sheds shall be vulcanized to the sheath (extrusion process) or moulded as part of the sheath (injection moulding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection moulding shall be at high temperature & high pressure. Any seams / burrs protruding axially along the insulator, resulting from the injection moulding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

End Fittings

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

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

Grading Rings

Grading rings shall be used at both ends of each composite insulator unit for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/corona cutting/ exceeding of permissible electrical stress of material. The insulator

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contractor shall furnish design calculations using appropriate electric field software showing electric field at surface of housing, inside housing & core and at the interface of housing and metal fittings with the proposed placement and design of corona. Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

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

5.5.9 Workmanship

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

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

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.

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

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

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

All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/sq.m. and shall be in accordance with the requirement of ISO:1461 (E) and shall satisfy the tests mentioned in ISO:1460 (E). The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. The galvanizing shall be carried out only after any machining.

The contractor shall guarantee that there shall not be any failure/ decapping / breaking of insulators on line under normal operating condition. In the event of any failure/ decapping /breaking of insulators during the first ten years of service, Contractor shall supply to the owner free of cost spare insulators equal to 10 times the failed insulator quantity. Further, in case of decapping / Breaking and subsequent line drop, during the first ten years of service, the contractor shall also have to pay Rs 50,000/ (Rs Fifty Thousand only) per dropped string towards expenditure to be incurred by RVPN for this line repair.

5.6 TESTS AND STANDARDS

5.6.1 TESTS

The following acceptance and routine tests and tests during manufacture shall be carried out on the material . The certificates for the type tests as listed below are required to be furnished. For the purpose of this Clause:-

- 5.6.1.1 Type tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this specification. The test reports for

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these tests shall be furnished by the contractors as per the requirement of clause no. 1.1 "Technical Evaluation " of section 3, EQC.(Vol I)

- 5.6.1.2 Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-despatch inspection, for the purposes of acceptance of that lot.
- 5.6.1.3 Routine tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.
- 5.6.1.4 Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Supplier to ensure the desired quality of the end product to be supplied by him.
- 5.6.1.5 The Standards and norms to which these tests will be carried out are listed against them. Where a particular test is a specific requirement of this specification, the norms and procedure of the test shall be as specified in Annexure-A or as mutually agreed to between the Supplier/ contractor and the Employer in the Quality Assurance programme.
- 5.6.1.6 For all type and acceptance tests, the acceptance values shall be the values specified in this specification or guaranteed by the Bidder, as applicable.

5.7 TYPE TESTS

The following shall constitute the type tests :

5.7.1 On each type of Disc Insulator / Long rod insulators unit

(a)	Verification of dimensions	IEC:60383
(b)	Thermal mechanical performance test	Annexure-A
(c)	Power frequency voltage withstand and flashover Test (i) dry (ii) wet condition	IEC:60383
(d)	Impulse voltage withstand and flashover test (dry)	
(e)	Visible Discharge test (dry)	IS:731
(f)	RIV test (dry)	IEC:60437
(g)	Residual strength Test (only on disc insulators)	Annexure-A
(h)	Steep wave front test (only on disc insulators)	
(i)	Impact Test (only on disc insulators)	

5.7.2 On Composite Insulator Units

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

5.7.3 On the complete Disc/Long rod Insulator String with Hardware Fittings

(a)	Power frequency voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	IEC:383
(b)	Switching surge voltage withstand test under wet condition	
(c)	Impulse voltage withstand test under dry condition	
(d)	Impulse voltage flash over test under dry condition	
(e)	Voltage distribution test (only on disc insulators string)	Annexure-A
(f)	Corona and RIV test under dry condition	
(g)	Mechanical Strength test	
(h)	Vibration Test	

5.7.4 All the above mentioned type tests are conducted on all the insulator strings alongwith hardware fittings. However, vibration test shall not be conducted on pilot string.

5.8 ACCEPTANCE TESTS

5.8.1 For Insulator Unit

(a)	Visual examination	IEC:383
(b)	Verification of dimensions	
(c)	Temperature cycle test	
(d)	Galvanising Test	
(e)	Mechanical Performance Test	IEC:575
(f)	Test on locking device for ball and socket coupling	IEC:372
(g)	Eccentricity Test	IEC:383
(h)	Residual Strength Test (only on disc insulators)	IEC:797
(i)	Metallurgical Test { For Metal fittings only (in Black condition)}	Annexure-A
	(i) Grain size	
	(ii) Inclusion rating	
	(iii) Chemical Analysis	
	(iv) Microstructure	
(j)	IR measurement (only on disc insulators)	IEC:383
(k)	Impact Test (only on disc insulators)	
(l)	Electro-mechanical Strength Test	
(m)	Porosity test (only on porcelain insulators)	
(n)	Puncture test (only on disc insulators)	IEC : 60383
(o)	Thermal shock test (only on glass insulators)	
	On composite long rod insulator	
(p)	Verification of dimension	IEC : 61109
(q)	Galvanising test	IEC : 60383
(r)	Verification of end fittings	Annexure-A
(s)	Recovery of Hydrophobicity	IEC : 61109
(t)	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IEC : 61109
(u)	Tests on interfaces and connections of metal fittings	IEC : 61109
(v)	Silicon content test	Annexure-A
(w)	Brittle fracture test	IEC : 61109
(x)	Dye penetration test	IEC : 61109
(y)	Water diffusion test	IEC : 61109
	The test (u) to (y) shall be carried out as acceptance test on any one lot. In the event of failure of the sample to satisfy the acceptance test(s) specified above, the retest procedure shall be as per IEC 61109	

5.9 ROUTINE TESTS**5.9.1 On Disc Insulator/ long rod insulator unit**

(a)	Visual Inspection	IS:731
(b)	Mechanical routine test	
(c)	Electrical routine test (only on porcelain disc insulators)	
(d)	Thermal shock test (only on glass insulators)	

5.10 TESTS DURING MANUFACTURE**On all components as applicable**

(a)	Chemical analysis of zinc used for galvanising	Annexure-A
(b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings	
(c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	Annexure-A
(d)	Hydraulic Internal Pressure tests on disc insulator shells	
(e)	Autoclave Test on cement	
(f)	Tracking and erosion test on insulated material	IEC:60587

5.11 TESTING EXPENSES

- 5.11.1 Testing charges for all acceptance, routine test (s) and tests during manufacture required to be carried out as per requirement of the specification shall be in-built /included by the bidder in the prices of material/equipments quoted by him in Schedules of Prices and no additional charges shall be paid by the Employer on this account.

5.12 SAMPLE BATCH FOR TYPE TEST(Not Applicable)**5.13 SCHEDULE OF TESTING(Not Applicable)****5.14 ADDITIONAL TESTS**

- 5.14.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the specifications.
- 5.14.2 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site, at Supplier's premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of the Supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Employer.

5.15 CO-ORDINATION FOR TESTING

- 5.15.1 The contractor shall have to co-ordinate testing of insulators with hardware fittings to be supplied by other manufacturer and shall have to guarantee overall satisfactory performance of the insulators with the hardware fittings.

5.16 GUARANTEE

The contractor shall guarantee overall satisfactory performance of the insulators with the hardware fittings.

5.17 INSPECTION

5.17.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where Insulators shall be manufactured and representative shall have full facilities for unrestricted inspection of the contractor's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

5.17.2 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of Insulators in its various stages.

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

5.17.4 The acceptance of any quantity of material shall in no way relieve the contractor of any of his responsibilities for meeting all requirements of the specification, and shall not prevent subsequent rejection if such material is later on found to be defective.

5.18 TYPE TEST CERTIFICATES/REPORTS

5.18.1 The Bidder must furnish certified photocopies of all the type test certificates/reports for the tests specified in the latest editions of relevant IS as per requirement of clause no. 1.1 "Technical Evaluation " of section 3 of EQC.(Vol I). The drawing number of the samples on which type tests were conducted should be clearly stated in the test report.

5.18.2 Record of routine test reports shall be maintained by the supplier at his works for periodic inspection by the Employer's representative.

5.18.3 Test Certificates of tests carried out during manufacture shall also be maintained by the contractor. These certificates shall be produced for verification as and when desired by the Employer.

5.19 TESTING FACILITIES

5.19.1 The bidder must indicate clearly about the various testing facilities for routine/ acceptance tests as per relevant ISS/IEC in respect of disc insulator, insulator strings & hardwares and accessories available at the works of his supplier. In case no testing facilities are available at the works of their supplier, particulars of the place where such testing is proposed to be conducted during the course of inspection must be indicated.

5.20 SCALE OF SAMPLING AND CRITERIA FOR CONFORMITY

The scale of sampling and criteria for conformity shall be as per Approved Standard Manufacturing Quality Plan.

5.21 QUALITY ASSURANCE

5.21.1 To ensure that the equipment covered under the scope of this specification, whether manufactured within the Supplier's Works or at his Sub-Supplier's premises, is in accordance with the specifications, the Supplier shall adopt suitable Quality Assurance programme to control such activities at all necessary points.

5.21.2 Such programme shall be outlined by the Supplier and shall be finally accepted by the Employer after discussions before the award of contract. A Quality Assurance Programme of the Supplier/Manufacturer shall generally cover but not limited to the following:

a)	His organisation structure for the management and implementation of the proposed Quality Assurance Programme.
b)	Documentation control system.
c)	Qualification data for key personnel.
d)	The procedure for purchases of materials. Parts/components and selection of sub-Supplier's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
e)	System for shop manufacturing including process controls.
f)	Control of non-conforming items and system for corrective action.
g)	Control of calibration and testing of measuring and testing equipment.
h)	Inspection and test procedure for manufacture.
i)	System for indication and appraisal of inspection status.
j)	System or quality audits.
k)	System for authorising release of manufactured product to the Employer.
l)	System for maintenance of records.
m)	System for handling, storage and delivery and
n)	A Quality Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics of the product.

The Quality Assurance Programme shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Supplier / contractor as may be required.

5.22 QUALITY ASSURANCE DOCUMENTS

5.22.1 The supplier shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Assurance Programme at the time of Employer's inspection of equipment/material.

5.22.2 The Employer or his duly authorised representatives reserves the right to carry out Quality Audit and quality surveillance of the system and procedures of the Supplier's/his vendor's Quality Management and Control Activities.

5.23 PACKING

All insulators shall be packed in suitable crates or boxes with suitable steel bands so as to withstand rough handling and storage at destination. Insulators of same batch nos., month & year of manufacture shall be packed in each crate/ box.

5.24 MARKINGS

Each insulator shall be legibly and indelibly marked before firing to show the following:-

- i) Name or trade mark of the manufacturer.
- ii) Batch No., month and year of manufacture.
- iii) Minimum failing load in kNewton.
- iv) Name of RVPN.
- v) One 10 mm thick ring of suitable quality of paint shall be marked on the cap of each insulator of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark :
For 120 kN Disc Insulator/Long rod unit :- Orange
For 160 kN Disc Insulator/ Long rod unit :- Green

Insulators may also be marked with the certification mark. For toughened glass insulators the marking shall be on the metal parts.

5.25 DRAWINGS

The Bidder shall submit detailed drawings showing design and dimensions of insulator, insulator strings, pin ball, socket cap & security pin. The type of the material used for various parts shall be clearly specified on the drawing.

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5.26 GUARANTEED AND OTHER TECHNICAL PARTICULARS

The guaranteed technical particulars to be adhered by the contractor/ manufacturer are furnished as below:

5.26.1 STANDARD TECHNICAL PARTICULARS FOR INSULATOR STRING FOR 400 KV LINE.

Standard Technical Particulars for Standard Disc Insulators

S. No.	Description	Unit	Standard Technical Particular value of Disc insulator	
			120 KN	160 KN
1	General			
	Size and Designation of pin ball shank	mm	20 as per IS: 2468/ IEC 120	
2	Dimensions			
a)	Diameter of disc	mm	255/280	280
b)	Tolerance on Diameter	\pm mm	11.0/13.0	13.0
c)	Ball to ball spacing between Disc	mm	145	170
d)	Tolerance on spacing	\pm mm	4	5
e)	Minimum nominal creep age distance of single disc	mm	320	330
3	Materials			
	Colour of glaze of finished porcelain insulator		Brown	Brown
4	Electromechanical Strength of disc	KN	120	160
5	Minimum Electrical values			
a)	Power frequency Flashover voltage DRY / WET	kV (rms)	75 / 45	78 / 48
b)	Power frequency Withstand voltage DRY / WET	kV (rms)	70 / 40	72 / 42
c)	Impulse Flashover test voltage 1.2 x 50 μ s (Dry) POSITIVE / NEGATIVE	kV (peak)	115 / 120	120 / 125
d)	Impulse Withstand test voltage 1.2 x 50 μ s (Dry) POSITIVE / NEGATIVE	kV (peak)	110 / 110	115 / 115
e)	Steepness of impulse voltage (steep wave front test)	kV/us	2500	2500
6	Power frequency puncture voltage	kV (rms)	120	125
7	Minimum Visible discharge voltage of single disc (dry)	kV (rms)	18	18
8	Maximum RIV at 1 MHZ and 10kV AC (rms) voltage of single disc	Micro-volts	50	50
9	Eccentricity of disc			
a)	Max. radial run out	mm	7.145/ 8.84	8.4
b)	Max. axial run out	mm	10.2/ 11.2	11.2
10	Galvanising			
a)	Minimum mass of zinc coating	gm/m ²	600	600
b)	Minimum no. of one minute dips in the standard preece test	Nos	6 dips	6 dips
c)	Minimum purity of zinc used for galvanising	%	99.95	99.95

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5.27.2 Standard Technical Particulars of insulator strings with Standard Disc Insulators along with hardware fittings

S. No.	Description	Unit	Standard Technical Particular value			
			Single Suspension I-String	Double Suspension I-String	Double Tension String.	Single Suspension Pilot String
			1x23 (120kN)	2 x 24 (120kN)	2 x 23 (160kN)	1x23 (120kN)
1	Mechanical strength of complete insulator string alongwith hardware fittings	kN	120	240	320	120
2	Power frequency withstand volt-age of string with arcing horns, corona control rings/ grading rings under wet condition	kV (rms)	680			
3	Switching withstand voltage (dry)					
a	Positive (Peak)	kV	1050			
b	Negative (Peak)	kV	1050			
4	Impulse withstand voltage (dry)					
a	Positive (Peak)	kV	1550			
b	Negative (Peak)	kV	1550			
5	Minimum corona extinction voltage under dry condition	kV (rms)	320			
6	RIV at 1 MHZ when string is energised at 305 kV (rms) under dry condition	Micro volts	1000 (max.)			
7	Maximum voltage distribution across any disc of line to earth voltage	%	9	9	10	9

5.27.3 Standard Technical Particulars for Porcelain Long Rod Insulators

S.No	Description	Unit	Standard Technical Particular value	
			120 KN Standard Insulator	160 KN Standard Insulator
1	General			
a)	Size and Designation of ball & Socket assembly	mm	20 as per IS 2468/ IEC 120	
2	Dimensions			
a)	Core diameter	mm	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	0.04d+1.5	0.04d+1.5
c)	Minimum nominal creepage distance of single unit	mm	2415	2530
3	Colour of glaze of finished porcelain insulator		Brown	
4	Mechanical Strength of insulator unit	kN	120	160
5	Minimum electrical values			
a)	Power frequency Flashover voltage Dry / Wet	kV(rms)	270 / 240	290 / 250
b)	Power frequency Withstand voltage Dry / Wet	kV(rms)	250 / 230	270/ 230
c)	Impulse Flashover test voltage 1.2 x 50 µs (Dry) Positive / Negative	kV(peak)	550 / 570	550 / 570
d)	Impulse Withstand test voltage 1.2 x 50 µs (Dry) Positive / Negative	kV(peak)	500 / 510	500 / 510
6	Eccentricity of disc			

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S.No	Description	Unit	Standard Technical Particular value	
			120 KN Standard Insulator	160 KN Standard Insulator
a)	Max. axial/radial run out		1.2 % of insulator length	
b)	Max. angular displacement	deg	15	15
7	Galvanising			
a)	Minimum mass of zinc coating	Gm/ sq.m.	600	600
b)	Minimum no. of one minute dips in the standard preece test	Nos.	6 dips	6 dips
c)	Minimum purity of zinc used for galvanising	%	99.95	99.95

5.27.4 Standard Technical Particulars of insulator strings with Long rod insulators alongwith hardware fittings

S. No.	Description	Unit	Standard Technical Particular value			
			Single 'I' Suspension string 1x3 (120kN)	Double 'I' Suspension string 2x3 (120kN)	Single 'I' Suspension Pilot string 1x3 (120kN)	Double Tension String 2x3 (160kN)
1	Nominal length of insulator string.	mm	3335 ± 92			3910± 120
2	Power frequency withstand voltage of string with arcing horns, corona control rings/grading rings under wet condition	kV (rms)	680			
3	Switching withstand voltage (dry)					
a)	Positive	kV (Peak)	1050			
b)	Negative	kV (peak)	1050			
4	Impulse withstand voltage (dry)					
a)	Positive	kV (Peak)	1550			
b)	Negative	kV (peak)	1550			
5	Minimum corona extinction voltage under dry condition	kV (rms)	320			
6	RIV at 1 MHZ when string is energised at 305 kV (rms) under dry condition	Micro volts	1000 (max.)			
7	Mechanical strength of complete insulator string alongwith hardware fittings	kN	120	240	120	2x160

* As per IEC-60-1

PROCEDURES FOR TESTING ON INSULATORS**1 Tests on Complete Strings with Hardware Fittings****1.1 Voltage Distribution Test (for Standard disc insulator only)**

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted in to percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings.

1.2 Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 320 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 383.

1.3 RIV Test (Dry)

Under the conditions as specified at (1.2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 305 kV (line to ground) under dry condition. The test procedure shall be in accordance with IS: 8263/IEC: 437.

1.4 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to 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 load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 VIBRATION TEST

The suspension string shall be tested in suspension mode and tension string in tension mode itself in laboratory test span of minimum 30 meters. In the case of suspension string, a load equal to 600 kg. shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and two sub conductors (each tensioned at 43 kN) shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators sting (more than 10 Hz) by means of vibration inducing equipment. The peak-to-peak displacement in mm of vibration at the antinodes point, nearest to the string, shall be measured and the same shall not be less than $1000/f^{1.8}$ where f is the frequency of vibration in Hz. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the following tests as per relevant standards:

S. No.	Tests	Percentage of insulator units to be tested	
		Disc Insulators	Long Rod Insulator
a.	Temperature cycle test followed by mechanical performance test	60	100
b.	Puncture test/steep wave front test	40	--

2. On Insulator Units.**2.1 Steep wave Front Test**

The following tests shall be performed on 10 insulator units in case of disc insulators selected at random from the lot offered for selection of sample for type test.

- a) Each insulator unit shall be subjected to five successive positive and negative impulse flashovers with a wave having minimum effective rate of rise of 2500 kV per microsecond.
- b) Each unit shall then be subjected to three dry power frequency voltage flashover.

Acceptance Criteria

An insulator shall be deemed to have met the requirement of this test if, having been successfully subjected to the ten impulse flashover, the arithmetic mean of the three subsequent dry power frequency voltage flashover values equals or exceeds 95% of the rated dry power frequency flashover voltage.

An insulator shall be deemed to have failed to meet the requirement of above testing if,

- a) It has not flash over when the oscillogram or peak voltage indicator shows a marked reduction in voltage.
- Or
- b) Any one of the subsequent three dry power frequency voltage flashover values is less than 80% of the value specified.

Failure of any one unit, either in the steep wave front or subsequent low frequency voltage test, shall cause for testing on double number of units.

2.2 Hydraulic Internal Pressure Test on Shells (on Disc Insulators).

The test shall be carried out on 100% shells before assembly. The details regarding test will be as discussed and mutually agreed to by the contractor and Employer in Quality Assurance Programme.

2.3 Thermal Mechanical Performance Test

Thermal Mechanical Performance Test shall be performed in accordance with IEC-383-1-1993 Clause 20 with the following modifications:

- (1) The applied mechanical load during this test shall be 70% of the rated electromechanical or mechanical value.
- (2) The acceptance criteria shall be
 - a) X greater than or equal to $R + 3 S$

Where

X Mean value of the individual mechanical failing load.

R Rated electro-mechanical/mechanical failing load

S Standard deviation.

- b) The minimum sample size shall be taken as 20 for disc insulator units & 5 for long rod insulator units. However, for larger lot size IEC .591 shall be applicable.
- c) The individual electro-mechanical failing load shall be at least equal to the rated value. Also puncture shall not occur before the ultimate fracture.

2.4 Electromechanical/Mechanical failing Load Test.

This test shall be performed in accordance with Clause 18 and 19 of IEC 383 with the following acceptance

- i) X greater than or equal to $R + 3 S$
Where

X Mean value of the electro-mechanical/mechanical/ failing load.

R Rated electro-mechanical/mechanical failing load

S Standard deviation

- ii) The minimum sample size shall be taken as 20 for disc insulator units & 5 for long rod insulator units. However, for larger lot size IEC .591 shall be applicable. However, for larger lot size, IEC 591 shall be applicable.
- iii) The individual electro-mechanical/mechanical failing load shall be at least equal to the rated value. Also electrical puncture shall not occur before the ultimate fracture.

2.5 Residual Strength Test (on Disc Insulators).

The above test shall be performed as per Clause 4.4 and 4.5 of IEC 797 preceded by the temperature cycle test, on porcelain disc insulators. The sample size shall be 25 and the evaluation of the results and acceptance criteria shall be as per Clause No. 4.14 of IEC: 797.

2.14 IR Measurements

IR measurement shall be carried out by the instrument operating at $\pm 5/10$ kV DC. IR value when measured under fair weather condition, shall not be less than 2000 M-ohm.

2.7 Impact Test

The Impact Test shall be carried out in accordance with ANSI-C-29.2-1992 Clause 8.2.8 with the following modification.

The breaking point of the pendulum shall be so adjusted that, when released, the copper nose will strike the outer rim of the shell or the most protuded rim of the shell squarely, a direction parallel to the axis of the unit and towards the cap.

The test specimen shall receive an impact of 7 N-m for 120 kN Disc and 10N-m for 160 kN disc by releasing the pendulum.

3. Test on All components (As applicable)

3.1 Chemical Analysis of Zinc used for galvanizing.

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

3.2 Tests for Forgings

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

3.3 Tests on Castings

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

3.4 Autoclave Test

For cement used in the assembly of the insulators six samples from different batches shall be tested in accordance with ASTM C-151. The cement shall have an expansion less than 0.12%.

4.1 Brittle Fracture Resistance Test

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO₃ acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. The rod shall withstand 80% of SML for 96 hours.

4.2 Recovery of Hydrophobicity Test

- (1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.
- (2) Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1". Continue treating this area for 2 – 3 minutes, operating the tester at maximum output.
- (3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.
- (4) Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

4.3 Silicone content test

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

4.4 High Pressure washing test

The washing of a complete insulator of each E&M rating is to be carried out at 3800 kPa with nozzles of 6 mm diameter at a distance of 3m from nozzles to the insulator, The washing shall be carried out for 10minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be 1 minute wet power frequency withstand test at 680kV r.m.s.

4.5 Torsion Test

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

CHAPTER-6**GALVANISED STEEL STRANDED GSS EARTHWIRE SIZE 7/3.146 MM**

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CHAPTER-6**GALVANISED STEEL STRANDED GSS EARTHWIRE SIZE 7/3.66 MM****6.1. SCOPE**

The scope covers for the manufacture, testing before despatch, supply and delivery of Galvanised Steel Stranded wire size 7/3.66 mm (981 N/mm sq.) for the purpose of earthing and protection of 400 kV double circuit transmission line.

6.2. STANDARDS

The galvanised steel stranded wire shall comply fully with the latest edition of Indian Standard Specification IS: 12776 and associated Indian Standard Specifications as mentioned therein. The earthwire shall also conform to the relevant following Indian Standards/International standards, which shall mean latest revision, amendments/changes adopted and published, unless otherwise specified in the specification. The relevant standards shall include the following.

IS:2363	Glossary of terms relating to wire ropes (first revision)
IS:398(Part-II)	Aluminium conductors for overhead purposes: (Part-2). Aluminium conductors, galvanised steel reinforced
IS:2500 (Part-I)	Sampling inspection tables: (Part-I) Inspection by attributes and by count of defects (first revision)
IS: 4826	Hot dipped galvanized coatings on round steel wires (first revision)
IS:1778	Reels and Drums for Bare conductors
IS:209	Specification for zinc
IS:398 (Part-V)	Aluminium conductor galvanized steel reinforced for extra high voltage (400 kV) and above.
IS:1521	Method of Tensile testing of steel wire
IS:2629	Recommended practice for Hot Dip galvanising of iron and steel
IS:2633	Method of testing uniformity of coating of zinc coated articles
IS:4826	Galvanised coating on round steel wires
IS: 6745	Method of determination of weight of zinc coating of zinc coated iron and steel articles
IEC:888	Zinc coated steel wires for stranded conductors
IEC:889	Hard drawn aluminium wire for overhead line conductors

In the event of the supply of GSS earthwire conforming to standards other than specified, the Contractor shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the contractor and those specified in this document will be provided by the contractor to establish their equivalence.

6.3 PRINCIPAL TECHNICAL PARAMETERS

S.No	Description	Size of GSS earthwire.
1.	Type	Galvanised Stranded Steel wire.
2.	Stranding and wire size.	7/3.66 mm
3.	Wire Size (mm)	
	a) Standard	3.66
	b) maximum	3.73
	c) minimum	3.59
	d) Minimum breaking load of strand (After stranding) (kN)	10.58
	d) No. of strands	
	i.) Inner layer	1
	ii.) Outer layer	6
4.	Total sectional area (sq. mm)	73.65
5.	Approximate overall diameter (mm)	10.98
6.	Minimum tensile strength of wire before stranding (N/mm Sq.)	981
7.	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding	18
8.	Zinc coating on wires:	
	a) amount of coating (g/ m ²)	290
	b) Uniformity of coating	4 dips of one minute
	c) Minimum purity of Zinc (%)	99.95
9.	Strand lay & lay length (mm)	RH Min. – 165, Max. – 198, Nom. – 181
10.	Approximate min. breaking load of complete wire (kN)	68
11.	Mass per KM of strand (Kg.) approx.	583
	a) Linear mass (Kg/km)	
	i) Standard	583
	ii) Maximum	600
	iii) Minimum	552
12.	Equivalent modules of elasticity (kg/ mmsq.)	19x10 ³
13.	Maximum D.C. resistance per KM of the wire at 20 degree C. (ohms)	2.5
14.	Co-efficient of linear expansion per Deg. C.	11.5x10 ⁻⁶
15.	Minimum elongation of individual wire on 200 mm galvanised length after breakage	4%
16.	Density of high tensile galvanised steel wire at a temp. of 20 Deg. C. (gm/cubic cm.)	7.8
17.	Standard length of earth wire (Mtr.)	2000
18.	Tolerance on standard length (%)	± 5

6.4 WORKMANSHIP

- 6.4.1 All steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions and kinks after drawing and also after stranding.
- 6.4.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibrations while in use.
- 6.4.3 The steel strands shall be hot dip galvanized and shall have minimum, zinc coating of 290 gms/sqm. after stranding. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand four dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-M.
- 6.4.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earthwire. Care shall be taken to avoid damage to galvanization during preforming and post- forming operation.
- 6.4.5 To avoid susceptibility towards wet storage strains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

6.5 MATERIALS

- 6.5.1 The steel wire strands shall be drawn from high carbon steel rods of best quality and workmanship and shall have the following chemical composition.

S. No.	Element	Percentage composition
i)	Carbon	0.55 max.
ii)	Manganese	0.4 to 0.9
iii)	Phosphorous	0.04 max.
iv)	Sulphur	0.04 max.
v)	Silicon	0.15 to 0.35

- 6.5.2 The Zinc used for galvanisation shall be electrolytic High Grade Zinc of 99.95 % purity. It shall conform to and satisfy all requirements of IS: 209.

6.6 TESTS AND STANDARDS**6.6.1 TESTS**

The following acceptance and routine tests and tests during manufacture shall be carried out on the material. The certificates for the Type tests as listed below are to be furnished. For the purpose of this clause:-

- 6.6.1.1 Type tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this specification. These tests reports for these tests shall be furnished by the contractor as per the requirement of clause no. 1.1 "Technical Evaluation" of section 3, EQC (vol I).
- 6.6.1.2 Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-despatch inspection, for the purpose of acceptance of that lot.
- 6.6.1.3 Routine tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.
- 6.6.1.4 Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Supplier to ensure the desired quality of the end product to be supplied by him.
- 6.6.1.5 The norms and procedure of sampling for these tests will be as per relevant standards/ the Quality Assurance programme.

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6.6.1.6 The Standards and norms to which these tests will be carried out are listed against them. Where a particular test is a specific requirement of this specification, the norms and procedure of the test shall be as specified in Annexure-A or as mutually agreed to between the Supplier and the Employer in the Quality Assurance programme.

6.6.1.7 For all type and acceptance tests, the acceptance values shall be the values specified in this specification or guaranteed by the Bidder, as applicable.

6.7 TYPE TESTS:

The following shall constitute the Type tests :

(a)	UTS test
(b)	DC resistance

6.7.2 SAMPLE BATCH FOR TYPE TESTS.(Not Applicable)

6.8 ACCEPTANCE TESTS:-

The following acceptance tests shall be carried on ten (10) percent drums from each lot offered for inspection.

6.8.1 ACCEPTANCE TESTS ON GSS EARTHWIRE.

(a)	Overall Diameter
(b)	Lay length & direction
(c)	Breaking load/UTS
(d)	DC Resistance Test
(e)	Joints (Visual Check)
(f)	Surface smoothness & Cleanliness (Visual check)
(g)	Preforming & Postforming

6.8.2 ACCEPTANCE TESTS ON INDIVIDUAL GALVANISED WIRE

(a)	Diameter
(b)	Breaking load/Tensile test
(c)	Elongation
(d)	Torsion
(e)	Wrapping Test
(f)	DC Resistance Test
(g)	Precee Test
(h)	Weight of Zinc Coating
(i)	Adhesion Test

6.8.3 MICROSTRUCTURE

(a)	Structure
(b)	Grain Size
(c)	Inclusion Rating
(d)	Surface Defects
(e)	Decarburisation
(f)	Chemical analysis

6.8.4 LENGTH MEASUREMENT OF COMPOSITE EARTHWIRE

Check for joints, surface finish and length measurement by rewinding Atleast 10 % of the total drums of GSS earthwire offered for inspection shall be subjected to verification of length and manufacturing defects, if any, by way of rewinding. All facilities for rewinding of the GSS earthwire drums shall be provided during inspection by the supplier to the authorised representative of Employer.

6.8.4 WOODEN DRUMS

- (a) Dimensions
- (b) Barrel Batten Strength test

6.9 ROUTINE TESTS

6.9.1 ROUTINE TESTS ON GSS EARTHWIRE

- a) Check for correctness of stranding
- b) Check that there are no cuts, fins etc. on the strands.
- c) Check that drums are as per specification.

6.10 LENGTH AND JOINTS

6.10.1 STANDARD LENGTH

The GSS earthwire shall be supplied in the standard length of 2000 metres. A tolerance of $\pm 5\%$ on standard length shall be allowed as per IS.

6.10.2 JOINTS IN WIRES

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earthwire. There shall be no strand joints or strand splices in any length of completed stranded earthwire.

6.11 TESTING EXPENSES

Testing charges for all acceptance, routine test (s) and tests during manufacture required to be carried out as per requirement of the specification shall be built-in/included by the bidder in the prices of material/equipments quoted by him in schedules of prices and no additional charges shall be paid by the Employer on this account.

6.12 SCHEDULE OF TESTING(Not Applicable)

6.13 ADDITIONAL TESTS

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

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

6.14 INSPECTION

6.14.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where GSS earthwire shall be manufactured and representative shall have full facilities for unrestricted inspection of the contractor's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

6.14.2 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of GSS earthwire in its various stages so that arrangements can be made for inspection.

6.14.3 No material shall be despatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the later case also the GSS earthwire shall be despatched only after satisfactory testing for all tests specified herein have been completed.

6.14.4 The acceptance of any quantity of material shall in no way relieve the contractor of any of his responsibilities for meeting all requirements of the specification and shall not prevent subsequent rejection if such material is later found to be defective.

6.15 TYPE TEST CERTIFICATES/REPORTS

6.151 The Bidder must furnish certified photocopies of all the type test certificates/reports for the tests specified in the latest editions of relevant IS as per requirement of clause no. 1.1 , Technical Evaluation of section 3, EQC (Vol I)..

6.15.2 Record of routine test reports shall be maintained by the supplier at his works for periodic inspection by the Employer's representative.

6.15.3 Test Certificates of tests carried out during manufacture shall also be maintained by the contractor. These certificates shall be produced for verification as and when desired by the Employer.

6.16 TESTING FACILITIES

6.16.1 The bidder must indicate clearly about the various testing facilities for routine/ acceptance tests as per relevant ISS/IEC in respect of GSS earthwire available at the works of his supplier. In case no testing facilities are available at the works of their supplier, particulars of the place where such testing is proposed to be conducted during the course of inspection must be indicated.

6.16.2 The following additional test facilities shall be available at the Supplier's works:

- a) Calibration certificates of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.
- b) Standard resistance for calibration of resistance bridges.
- c) Finished GSS earthwire shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 metres per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc., with traverse laying facilities.

6.17 TEST PROCEDURES:

The procedures of various tests shall be as per Anneure-A/ relevant IS.

6.18 SCALE OF SAMPLING AND CRITERIA FOR CONFORMITY

The scale of sampling and criteria for conformity shall be as per Approved Standard Manufacturing Quality Plan.

6.19 QUALITY ASSURANCE.

6.19.1 To ensure that the material under the scope of this contract whether manufactured within the Supplier's Works or at his Sub-Supplier's premises, is in accordance with the specifications, the Supplier shall adopt suitable Quality Assurance programme to control such activities at all necessary points.

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- 6.19.2 Such programme shall be outlined by the Supplier and shall be finally accepted by the Employer after discussions before the award of contract. A Quality Assurance Programme of the Supplier shall generally cover but not limited to the following:

a)	His organisation structure for the management and implementation of the proposed Quality Assurance Programme.
b)	Documentation control system.
c)	Qualification data for key personnel.
d)	The procedure for purchases of materials. Parts/components and selection of sub-Supplier's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
e)	System for shop manufacturing including process controls.
f)	Control of non-conforming items and system for corrective action.
g)	Control of calibration and testing of measuring and testing equipment.
h)	Inspection and test procedure for manufacture.
i)	System for indication and appraisal of inspection status.
j)	System or quality audits.
k)	System for authorising release of manufactured product to the Employer.
l)	System for maintenance of records.
m)	System for handling, storage and delivery and
n)	A Quality Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics of the product.

The Quality Plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Supplier as may be required.

6.20 QUALITY ASSURANCE DOCUMENTS

- 6.20.1 The supplier shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Assurance Programme Plan at the time of Employer 's inspection of material.
- 6.20.2 The Employer or his duly authorised representatives reserves the right to carry out Quality Audit and quality surveillance of the system and procedures of the Supplier's/his vendor's Quality Management and Control Activities.

6.21 PACKING

- 6.21.1 The GSS earthwire shall be supplied in non-returnable, strong, wooden drums and provided with lagging of adequate strength, constructed to protect the GSS earthwire against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The contractor shall be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS: 1778-1980, except as otherwise specified hereinafter.
- 6.21.2 The drums shall be suitable for wheel mounting and for letting off the GSS earthwire under a minimum controlled tension of the order of 5 kN.
- 6.21.3 Two standard length shall be wound on each drum.
- 6.21.4 Each strand shall be individually welded to prevent parting of two lengths at a tension less than 15 kN. The two ends where the first length finishes and the second length starts, shall be clearly marked with adhesive tape and no weld should be present outside these marks. The length between the two marks shall be treated as scrap and will not be taken into account for measurement purposes.
- 6.21.5 A minimum space of 50 mm for GSS earthwire shall be provided between the inner surface of the external protective lagging and outer layer of the GSS earthwire.
- 6.21.6 Outside the protective lagging, there shall be minimum of two binders consisting of hoop iron/galvanised steel wire. Each protective lagging shall have two recesses to accommodate the binders.

- 6.21.7 The GSS earthwire ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the GSS earthwire layers during transit and handling.
- 6.21.8 All wooden components shall be manufactured out of seasoned softwood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the earthwire.
- 6.21.9 The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3 mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75 mm. Where a slot is cut in the flange to receive the inner end of the earthwire the entrance shall be in line with the periphery of the barrel.
- 6.21.10 The wooden battens used for making the barrel of the earthwire shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the earthwire.
- 6.21.11 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel studs shaft be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.
- 6.21.12. Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.
- 6.21.13 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.
- 6.21.14 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp edges or allow the battens to be released due to corrosion.
- 6.21.15 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

6.22 MARKINGS

Each drum shall have the following information stenciled on it in indelible ink along with other essential data.

- (a) Contract /Award letter number
- (b) Name and address of consignee
- (c) Manufacturer's name and address
- (d) Drum number
- (e) Size of GSS earthwire
- (f) Length of GSS earthwire in meters
- (g) Gross weight of drum with GSS earthwire & without lagging
- (h) Weight of empty drum with lagging
- (i) Arrow marking for unwinding
- (j) Position of the GSS earthwire ends
- (k) Number of turns in the outer most layer
- (l) Distance between outer most layer of GSS earthwire and the inner surface of lagging
- (m) Barrel diameter at three locations and an arrow marking at the location of measurement

6.23 GUARANTEED AND OTHER TECHNICAL PARTICULARS

The Standard technical particulars to be adhered by the contractor/ manufacturer are furnished in below:

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S.No.	Description	Unit	Standard Values
1	Steel wires / rods		
a)	Carbon	%	Not more than 0.55
b)	Manganese	%	0.40 to 0.90
c)	Phosphorous	%	Not more than 0.04
d)	Sulphur	%	Not more than 0.04
e)	Silicon	%	0.15 to 0.35
2	Minimum purity of Zinc	%	99.95
3	Steel strands diameter		
a)	Nominal	mm	3.66
b)	Maximum	mm	3.73
c)	Minimum	mm	3.59
4	Minimum breaking load of strand after stranding		
5	Galvanising		
a)	Minimum weight of zinc coating per sq.m. after stranding	Gms.	290
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test.	Nos.	4 dips of 1 minute.
c)	Minimum number of twists in a gauge length equal to 100 times diameter of wire which the strand can withstand in the torsion test, after stranding.	Nos.	18
6	Stranded Earth wire		
a)	UTS of Earth wire	KN	68 (min.)
b)	Lay length of outer steel layer		
i)	i) Standard	mm	181
ii)	ii) Maximum	mm	198
iii)	iii) Minimum	mm	165
7	Maximum DC resistance of earth wire at 20 ⁰ C	Ohm/k m	2.5
8	Standard length of earth wire	M	2000
9	Tolerance on standard length	%	±5
10	Direction of lay for outside layer		Right hand
11	Linear mass		
a)	Standard	Kg/km	583
b)	Maximum	Kg/km	600
c)	Minimum	Kg/km	552

PROCEDURES FOR TESTING ON GSS EARTHWIRE**1. TESTS ON GSS EARTHWIRE****1.1 UTS Test**

Circles perpendicular to the axis of the GSS earthwire shall be marked at two places on a sample of GSS earthwire of minimum 5 m length suitably compressed with dead end clamps at either end. The load shall be increased at a steady rate upto 50% of UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of UTS and held for one minute. The GSS earthwire sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 D.C. Resistance Test

The test shall be conducted on a GSS earthwire sample of minimum 5 m length. Two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially at zero metre and subsequently one metre apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20°C. The resistance corrected at 20°C shall conform to the requirements of this specification.

1.3 Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in the specification.

1.4 Chemical Analysis of Steel

Samples taken from the steel ingots/coils/strands shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this specification.

1.5 Visual and Dimensional check on drums and its barrel strength test

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this specification. The details regarding barrel strength test will be discussed and mutually agreed to by contractor and Employer in the quality assurance programme.

1.6 Visual Check for joints, scratches etc. and Length of GSS earthwire

Ten percent drums from each lot shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and see that the GSS earthwire generally conforms to the requirements of this specification.

The length of GSS earthwire wound on the drum shall be measured with the help of counter meter during rewinding.

1.7 Dimensional Check

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this specification.

1.8 Lay Length Check

The lay length shall be checked to ensure that they conform to the requirements of this specification.

1.9 Galvanising Test

The test procedure shall be as specified in IS: 4826. The material shall conform to the requirements of this specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.10 Torsion Test

The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case test sample length is less or more than 100 times the stranded diameter of the strand the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number.

CHAPTER-7**HARDWARE AND LINE ACCESSORIES FOR CONDUCTOR AND EARTH WIRE
FOR 400 kV TRANSMISSION LINE**

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CHAPTER –7
HARDWARE AND LINE ACCESSORIES FOR CONDUCTOR
AND EARTH WIRE FOR 400 kV TRANSMISSION LINE.

7.1 SCOPE

The scope covers for design, manufacture, engineering, inspection & testing at manufacturer's works before despatch, supply of Hardware and accessories for Twin ACSR Moose Conductor and Earth Wire required for 400 kV transmission line.

7.2 STANDARDS

7.2.1 The Hardware fittings and accessories shall conform to the latest revision with amendments and revisions thereof of all related IS, ASTM, IEC including following Bureau of Indian Standards (IS), ASTM, IEC unless specifically stated otherwise in specification.

Standards	Titles
IS:731	Porcelain Insulators for overhead power lines with a nominal voltage greater than 1000 V
IS:2486	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 V
IS:2486(Part-I)	General Requirements and tests
IS:2486(Part-II)	Dimensional Requirement
IS:2486(Part-III)	Locking devices
IS:2486(Part-IV)	Tests for locking devices
IS: 2121(Pt. I & II)	Conductor and ground wire accessories for overhead power lines
IS: 2121(Pt. I)	Armour rods, binding wires and tapes for conductors
IS:2121(Pt. II)	Mid span joints and repair sleeves for conductors
IS:10162	Spacers for Twin Horizontal bundle conductor
IS:5561	Electric Power connectors
IS:10136	Selection of Disc insulator fittings for highest system voltage of 72.5 kV & above.
IS:9708	Stock bridge vibration dampers for overhead power lines
IS:1363	Hexagon head bolts, screws and nuts
IS:1363 (Part-I)	Hexagon head bolts, nuts
IS:1363(Part-II)	Hexagon head screws
IS:1363(Part-III)	Hexagon nuts (product grade C)
IS:1367	Technical supply conditions for threaded steel fasteners
IS:1367 (Part-I)	Introduction and general information
IS:1367 (Part-II)	Product grades and tolerances
IS:1367 (Part-III)	Mechanical properties and test methods for bolts, screws and studs with full load ability
IS:6639	Hexagonal bolts for steel structures
IS:2633	Methods of testing for uniformity of coating of zinc coated article
IS:2629	Recommended practice for hot dip galvanising of iron and steel.
IS:209	Specification for zinc
IS:1327	Methods of determination of mass of tin coatings of tinplate.
IS:4826	Hot dipped galvanised coatings on round steel wires
IS:1573	Electroplated coatings of zinc on iron and steel
IS:2004	Carbon steel forgings for general engineering purposes
IS:6745	Method for determination zinc coating on zinc coated iron & steel articles
BS:970 (Part-I)	General instructions and testing procedures specific requirements for Carbon and Carbon Manganese alloy and stainless steels
IS:3138	Hexagonal bolts and nuts
IS:4218	Metric Screw threads
IS:4172	Dimensions for radii under the heads of bolts and screws
IS:4206	Dimensions for nominal lengths and thread length for bolts, screws and studs
IS:1570	Schedules for wrought steels for general engineering purposes
IS:1570 Part-I	Schedules for wrought steel specified by tensile and/or yield properties
IS:6603	Stainless steel bars and flats
IS:2002	Steel plates for pressure vessels for intermediate and high temperature service

IS:7814	Phosphor bronze sheet, strip and foil
IS:2016	Plain washers (First revision)
IS:2062	Weldable structural steel (3 rd revision)
ASTM-D1171	Ozone test on Elastomer
IS-8263	Method of Determination of weight of Zinc coating of Zinc coated iron and steel articles
IEC:383	Test on insulators of ceramic material or glass for over head lines with a nominal voltage greater than 1000 V
IEC:437	Methods of RIV test of HV insulators
IEC:372	Locking devices
IEC:797	Residual strength of string insulator unit of glass or ceramic material for overhead line after mechanical damage of the dielectric

- 7.2.2 Conductor and earth wire Hardware fittings and accessories conforming to any other National or International standards are also acceptable provided always that such standards are equivalent to or better than the corresponding Standards specified above. However in such an event, the salient points of comparison between the Standards adopted and the standards quoted herein shall be detailed in the appropriate schedule with an authentic English version of such Standards.

7.3 PRINCIPAL PARAMETERS

- 7.3.1 Hardware fittings shall be suitable for single/double suspension insulator strings and single/double tension insulator strings to be used with Twin ACSR Moose conductor and earth wire. The other Principal Parameters of Earth wire are available in Chapter 6 of the Specification and while that of ACSR Moose conductor shall be as per relevant IS.
- 7.3.2 Each Hardware fitting shall be supplied complete in all respect and shall include all components and match with the insulator string of relevant IS. The principal parameters of insulator string characteristics are available in Chapter 5 of the specification
- 7.3.3 The supplier shall be responsible for satisfying himself that the Hardware fittings offered are complete and entirely suitable for the proposed attachment.
- 7.3.4 The Hardware fittings offered shall be suitable for employment of hot line maintenance techniques so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method and hot stick method. The Bidder should clearly establish in the Bid, the suitability of the fittings for hot line maintenance.

7.4 TYPES OF HARDWARE FITTINGS

- i) Hardware fittings with all components for single/double suspension insulator string ('I' type) with two armour grip type suspension clamps suitable for twin ACSR Moose conductor.
- ii) Hardware fittings with all components for single suspension insulator string with two envelop type suspension clamps for pilot string suitable for ACSR Moose conductor.
- iii) Hardware fittings for single/double tension insulator strings (compression type) suitable for ACSR Moose conductor.

7.4.1 TYPES OF CONDUCTOR ACCESSORIES

- i) Mid span compression joints
- ii) Repair sleeves.
- iii) 4 R type stock bridge vibration dampers.
- iv) Line spacers with retaining rod and jumper spacers.
- v) Power connectors.
- vi) Balancing weights (counter weight)

7.4.2 TYPES OF EARTH WIRE ACCESSORIES

- i) Mid span compression joints.
- ii) Repair sleeves
- iii) 4 R type stock bridge vibration dampers.
- iv) Suspension assembly with copper earth bond for earth wire.
- v) Tension assembly with copper earth bond for earth wire.

7.5 GENERAL TECHNICAL REQUIREMENTS

The technical requirements of the above individual accessories and Hardware are set out as under:

- 7.5.1 For single & double "I" suspension, pilot suspension, standard anchor shackle shall be supplied suitable for attaching to hanger/strain plate fixed with towers. The above shackle should be so arranged that the plane of shackle shall be transverse to the run of conductor. Standard shackle shall be supplied for attaching the double/single tension Hardware fittings suitable for strain plate fixed with tower.

7.5.2 CORONA AND RIV PERFORMANCE

Sharp edges and scratches shall be avoided on all the Hardware fittings. All surfaces must be clean, smooth, without cuts and abrasions or projections. The contractor must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

7.5.3 BALL AND SOCKET DESIGNATION

The dimensions of the ball and socket shall be of 20 mm designation for 120 kN and 160 kN disc insulators for suspension/tension string assembly. The designation should be in accordance with standard dimensions stated in IS: 2486 (Part-II).

7.5.3.1 BALL FITTINGS:

Ball fittings shall be made of Class IV steel as per IS: 2004 or of equivalent grade forged in one piece. They shall be normalized to achieve the minimum breaking strength specified on the respective drawings. Before galvanization of ball fittings, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimension below the requirement.

7.5.3.2 SOCKET FITTINGS:

Socket fittings shall be made of Class IV steel as per IS: 2004 or of equivalent grade and shall be forged in one piece. They shall be normalised to achieve the minimum breaking strength.

7.5.3.3 DIMENSIONS AND TOLERANCES:

- i) The dimensions and tolerances of pin balls and socket ends shall conform to IS: 2486 (Part-II) and shall be checked by the gauge therein after galvanising.
- ii) The pin balls shall be checked with the applicable 'G' gauges at least in two directions, one of which shall be across the line of die flashing, and the other 90 deg. to this line. "NO GO" gauges shall not pass in any direction.
- iii) The bearing surfaces of balls and machines sockets, before galvanizing, shall not have surface roughness more than 250 micro inches.
- iv) The bearing surface of socket ends shall be uniform about the entire circumference without depressions or high spots. The internal contour of the socket ends shall be concentric with the axis of fittings as per IS: 2486. The axis of the bearing surface of socket ends shall be coaxial with the axis of fittings with no appreciable tilting of the bearing surfaces with the axis of the fitting.

7.5.3.4 SECURITY CLIPS AND SPLIT PINS:

- i) Socket fittings shall be provided with R-shaped security clip in accordance with IS: 2486 (Parts III and IV) to provide positive locking against un-intentional dis-engagement of socket from the ball of the insulator. The security clip shall be humped to maintain the clip in the locked position and shall have both prongs spread to prevent complete withdrawal from the socket. The clip end shall not project outside the recess of socket when the clip is in locked position. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow separation of fittings.
- ii) The hole for the security clip shall be on the side of the socket opposite to the socket opening. The hole for the clip shall be counter sunk. The clip eye shall be of such design that the same may be engaged by a hotline clip puller to provide for disengagement under energised conditions.
- iii) The force required to pull the clip in to its unlocked position shall not be less than 50 N or more than 500 N.
- iv) The security clip shall be made of stainless steel of type AISI 302 or 304 or phosphor bronze as per IS:7814.
- v) Split pins shall be used with bolts & nuts.

7.5.4 YOKE PLATE/ LINK PLATE

- i) The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength. The yoke plates shall be either triangular or rectangular in shape as may be necessary. The design of Yoke plate shall take into account the most unfavourable loading conditions likely to be experienced as a result of dimensional tolerances for Insulators as well as components of Hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading rings ~~for~~ arcing horns.
- ii) The yoke plates/link plate shall be made of mild steel plate as per IS: 2062 Gr.A or equivalent standards. Shearing/cutting of the plates shall be clean without drawn or ragged edges. If the plates are flame cut mechanical guides shall be used. It shall be ensured that the grain of the yoke plate shall be in the direction of the tensile load. Design calculations i.e. for bearing and tensile strength, for deciding the dimensions of yoke plate shall be furnished by the bidder.
- iii) Holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs. The holes provided for bolts in the yoke plate should satisfy shear edge conditions as per Clause No. 8.10 of IS: 800.
- iv) All the corners and edges should be rounded off with a radius of at least 3 mm.

7.5.5 ARCING HORNS:

- i) Arcing Horns shall be made of mild steel rod. They shall be ball ended rod type or tubular type. The ball shall be welded to the rod with electric arc welding. The welded portion shall be suitably finished to obtain smooth curvature. The arcing horns shall be provided on tower side of the Hardware fittings.
- ii) The arcing distance between arcing horn and corona control rings/grading rings shall be 3050 mm under nominal dimensions of insulator for insulator strings.
- iii) The air gap shall be so adjusted to ensure effective operation under actual field conditions.

7.5.6 CORONA CONTROL RINGS/GRADING RINGS

- i) The corona control rings/grading rings shall be made of high strength aluminium alloy extruded tube of type 6063 or equivalent and shall have minimum wall thickness 2.5 mm. The same shall be heat treated to maintain consistency in material properties during service.

- ii) The ends of grading rings tube shall be sealed with welded aluminium caps.
- iii) Welding of grading ring/corona control ring shall be done with argon welding. The welded location shall be suitably grinded and shall not allow penetration of water inside the tube during service. The mechanical strength of welded joints shall not be less than 20 KN.
- iv) The grading ring/corona control ring shall be buffed and have brushed satin finish. No blammish shall be seen or felt while rubbing hand over the surface.
- v) If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded centre of the corona control ring/grading ring shall be grinded before buffing. Alternately, aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.
- vi) The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings so that it will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.
- vii) Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 60 mm. The ends of grading ring tube shall be sealed with welded aluminium cap duly buffed.

7.5.7 SAG ADJUSTMENT DEVICE

- i) The sag adjustment devices to be provided with single/double tension Hardware fittings shall be of three plate type. The sag adjustment device shall be provided with a safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.
- ii) Sag adjustment plate shall be made from high quality mild steel plate as per IS: 2062. The grain flow shall not be in a direction transverse to the tensile load. Cutting/shearing and drilling of holes shall be similar to those for yoke plate mentioned under clause 7.5.4.
- iii) The maximum length of the sag-adjustment device from the connecting part of the rest of the Hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be indicated in the drawing submitted with the Bid. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment device.
- iv) Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by bidder. The hole provided for bolts should satisfy shear edge conditions as per clause No. 8.10 of IS: 800 with latest amendments.

7.5.8 TURN BUCKLE

- i) The turn buckle is to be provided with single tension Hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.
- ii) The maximum length of the turn buckle from the connecting part of the Hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing. An adjustment of 150mm minimum shall be possible with turn buckle.

7.5.9 SUSPENSION ASSEMBLY

- i) The suspension assembly shall be suitable for Twin ACSR Moose conductor.

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- ii) The suspension assembly shall include either four free centre type suspension clamp along with standard preformed armour rods or four armour grip suspension clamps except for pilot insulator string for which four suitable envelope type suspension clamps shall be used.
- iii) The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.
- iv) The suspension clamp along with standard preformed armour rods/armour grip suspension clamps shall have slip strength between 20 to 29 KN.
- v) The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.
- vi) The suspension assembly/clamp shall be so designed that it shall minimise the static and dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall allow slipping of the conductor under unbalanced conductor tension in adjacent spans and broken wire conditions. It shall also withstand power arcs and have required level of corona/RIV performance.
- vii) In case, the magnetic power loss of the suspension assembly obtained during type testing of the same exceeds the value guaranteed by the Bidder in his bid, the materials shall be rejected outright or the same shall be accepted after suitable liquidated damages for non performance are assessed, which shall be recovered from the contract price. The decision of the employer, as regards the assessment of such liquidated damage, shall be final and binding. However, the liquidated damages thus assessed shall not be less than @ Rs. 135.00 per watt/suspension assembly.

ix) ARMOUR GRIP SUSPENSION CLAMP

- a) The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminium reinforcements and AGS preformed rod set.
- b) Elastomer insert shall be resistant to the effects of temperature up to 95 deg. C, ozone, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS preformed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene cushion and shall not leave any gap between the two when installed.
- c) The support housing of AGS clamps shall be forged out of aluminium alloy of type 6061 or equivalent. It shall be duly heat treated to achieve the specified tensile properties and to maintain consistent material characteristics during service.
- d) The aluminium reinforcement of neoprene cushion shall be extruded and formed out of aluminium alloy of type 6061 or equivalent.
- e) The retaining strap shall be extruded and then formed out of aluminium alloy of type 6061 or equivalent and duly heat treated.
- f) The elastomer cushion shall be moulded on the aluminium reinforcement.

x) AGS PREFORMED ARMOUR RODS

- a) The AGS preformed rod set suitable for ACSR 'Moose' conductor shall be used to minimise the stress developed in the conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamps as a result of unbalanced conductor tension in adjacent span and broken wire conditions. It shall also withstand power arcs, chafing and abrasion from suspension clamp and

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localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

- b) The preformed armour rod set shall have right hand lay and the inside diameter of the helics shall be less than the outside diameter of the conductor to grip the same tightly. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.
- c) The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of ACSR 'Moose' conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.
- d) The length and diameter of each rod shall be 2235 ± 25 mm and 9.27 ± 0.1 mm respectively. The tolerance in length of the rods in completed set should be within 13 mm between the longest and shortest rod. The ends of armour rods shall be parrot billed.
- e) The number of armour rods in each set shall be twelve. Each rod shall be marked in the middle with paint for easy applications on the line.
- f) The armour rod shall not lose their resilience even after five applications.
- g) The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).
- h) The ends of the armour rods shall be de-burred, ball ended or parrot bill ended. The parrot bill ended rod shall have slightly inward (towards the conductor) curvature at the ends so that the edge of the parrot bill end closely grips and rests on the conductor surface and does not remain in the air creating corona/RIV problems. The ends of the rods shall be buffed for improved electrical performance.

xi) ENVELOPE TYPE SUSPENSION CLAMP

The seat of the envelope type suspension clamp shall be smoothly rounded and suitably curved at the ends. The lip edges shall have rounded head. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Suspension hardware fittings for ACSR Moose Conductor shall be as per the table given below:

S.No	Description	Unit	Particulars / Value	
			Single/Double 'I'	Single 'I' Pilot
			AGS clamp	Envelope clamp
1.	Maximum Magnetic Power Loss of suspension assembly at sub conductor current of 600 amperes, 50Hz AC	Watt	4	8
2.	Slipping strength of suspension assembly(clamp torque Vs slip curve shall be enclosed)	kN	20-29	
3.	Particulars of standard/AGS Standard / AGS preformed armour rod set for suspension assembly.			
	a) No. of rods per set	No.	12	NA
	b) Direction of lay		Right Hand	NA
	c) Overall length after fitting on	Mm	2235	NA

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	conductor			
	d) Diameter of each rod	Mm	9.27	NA
	e) Tolerance in			NA
	i) Diameter of each rod	±mm	0.10	NA
	ii) Length of each rod	±mm	25	NA
	iii) Difference of length between the longest and shortest rod in a set.	±mm	13	NA
	g) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032	NA
	h) UTS of each rod	Kg/mm ² (Min)	35	NA
4.	Particulars of Elastomer (For AGS Clamp only)			
	a) Type of elastomer		Chloroprene / Neoprene	NA
	b) Shore hardness of elastomer		65 - 80	NA
	c) Temperature range for which elastomer is designed	°C	Upto 95°C	NA
	d) Moulded on insert		Yes	NA
5.	Mechanical Strength of Suspension fitting (excluding suspension clamp)	KN	120	120
6.	Mechanical Strength of suspension clamp.		70	70
7.	Purity of Zinc used for galvanising	%	99.95	
8.	Min. No. of dips in standard preece test the ferrous parts can withstand	No	a) Fasteners : 4 dips of 1 min b) Spring washers : 3 dips of 1 min c) All others : 6 dips of 1 min	

7.5.10 DEAD END ASSEMBLY

- i) The dead end assembly, suitable for ACSR 'Moose' conductor, shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I²R losses. The resistance of the clamp when compressed on the conductor shall not be more than 75% of the resistance of equivalent length of conductor.
- ii) Die compression length shall be clearly marked on each dead end assembly designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. It shall bear identification marks 'COMPRESSION ZONE' and 'NON COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. Tapered Aluminium filler plugs shall also be provided at the time of demarcation between compression and non-compression zone. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensions and dimensional tolerances of the cross section of aluminium and steel dead ends shall be as per the table given below:

S. No.	Item	Dimensions before compression		
		Inner dia (mm)	Outer dia (mm)	Length
1.	Aluminum dead end	34.40 ± 0.5	54.4 ± 1.0	735±5
2.	Steel dead end	11.01 ± 0.2	21 ± 0.5	250±5

S. No.	Item	Dimensions after compression		
		Corner to corner width (mm)	Face to face width (mm)	Length (Approx.)
1.	Aluminum dead end	43 ± 0.5	46 ± 0.5	785

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2.	Steel dead end	20.2 ± 0.5	17.5 ± 0.5	286
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- iii) The assembly shall not permit slipping or damage to or failure of the complete conductor or any part thereof at a load less than 95% of the minimum UTS of the conductor.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Tension hardware fittings for ACSR Moose Conductor shall be as per the table given below:

S.No.	Description	Unit	Particulars / Value	
			Single Tension	Double Tension
1.	Mechanical Strength of Tension fittings (excluding dead end clamp)	kN	120	320
2.	Type of Dead End assembly		Compression	
3.	Compression Pressure	MT	100	
4.	Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead end assembly	kN	153.2	
6.	Purity of Zinc used for galvanising	%	99.95	
7.	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos	a) Fasteners : 4 dips of 1 min b) Spring washers : 3 dips of 1 min c) All others : 6 dips of 1 min	

7.5.11 FASTENERS: BOLTS, NUTS & WASHERS

- i) All fasteners shall conform to IS:6639. Nuts & bolts shall be galvanised as per IS:1367 (Part-13)/ IS:2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.
- ii) Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS: 12427. Bolts should be provided with washer face in accordance with IS: 1363 (Part-1) to ensure proper bearing.
- iii) Nuts should be double chamfered as per the requirement of IS: 1363 (Part-III). It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size upto M16.
- iv) Fully threaded bolt shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.
- v) All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but not further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.
- vi) Flat washer and spring washer shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. Thickness of washers shall conform to IS: 2016.
- vii) To obviate bending stress in bolt, it shall not connect aggregate thickness more than three times its diameter.
- vii) Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.
- ix) Bolts may have either rolled or cut threads. Nuts may be threaded after galvanising to ensure clean threads but bolts shall not be threaded or re-threaded after galvanising. Nut threads shall be tapped over size to closely fit those of the galvanised bolt, with no un-necessary looseness

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but free enough to permit the nut to be turned freely with fingers over the entire threaded length.

- x) The bidder shall furnish bolt schedules giving thickness of components connected nut & washer, length of shank and the threaded portion of bolts and size of holes. Any other special details of this nature.
- xi) Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.
- xii) To ensure effective in-process Quality Control, it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in house. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this specification and IS: 14000 services Quality System standard.

7.5.12 MID SPAN COMPRESSION JOINTS FOR CONDUCTOR

- i) This shall be suitable for joining the two lengths of Moose conductor for 400 kV lines. The joint shall have conductivity more than the conductivity of an equivalent length of the conductor. The joint shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% (i.e. 153.2 KN) of the ultimate tensile strength of the conductor. The electrical resistance of the joint, after installation, shall not exceed 75% of the measured resistance of the equivalent length of the conductor.
- ii) The components of the joint shall consist of steel and aluminium sleeves for compression jointing the steel core and aluminium wires respectively. The steel sleeve shall not crack or fail during compression. The Brinell Hardness number of the steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall be manufactured and extruded out of EC grade aluminium with a purity of not less than 99.5%. Tapered aluminium filler plugs shall be provided at the line of demarcation between compression and non-compression zones.
- iii) The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Mid span compression Joint for ACSR Moose Conductor shall be as per the table given below:

S.No.	Description	Unit	Particulars/ Value	
			Aluminium Sleeve	Steel Sleeve
1.	Material of Joint		Aluminium of purity 99.5%	Mild Steel(Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinell hardness)	BHN	From 100 to 200	
3.	Weight of Zinc coating for steel sleeve	gm/m ²	600	
4.	Dimension of sleeve before compression		Aluminum sleeve	Steel sleeve
i)	Inside diameter	mm	34.00 ± 0.5	11.10 ± 0.2
ii)	Outside diameter	mm	54.00 ± 1.0	21.00 ± 0.5
iii)	Length	mm	735 ± 5	250 ± 5
5.	Dimensions of Sleeve after compression		Aluminum sleeve	Steel sleeve
i)	Outside dimension(Corner to corner)	mm	53.00 ± 0.5	20.20 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5	17.50 ± 0.5
iii)	Length	mm	785 (approx)	286 (approx)
6.	Slip strength	KN	153.2	
7.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
8.	Minimum Corona Extinction voltage kV (rms)	kV	320	

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	under dry condition		
9.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition.	Micro Volts	1000
10.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	600
b)	Purity of Zinc used for galvanising	%	99.95
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	6 dips of 1 minute

7.5.13 REPAIR SLEEVES FOR CONDUCTOR

- i) Repair sleeve shall be used for repairing the conductor when a few strands of the aluminium conductor in the outer most layer are damaged with scratches, kinks, abrasions, nicks or cuts. Sleeve shall be of the compression type. The sleeve shall be manufactured and extruded out of EC grade aluminium having a purity of 99.5%. The sleeve shall be in two halves with a seat provisions for sliding of the keeper piece. The edges of the seat as well as of the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The outer body of the sleeve shall be smooth, even and with rounded off edges. The compressed conductor with the repair sleeve shall not permit damage or failure of the conductor at a load of not less than 95% of the ultimate tensile strength of the conductor. The electric resistance of the repaired portion of the conductor shall not exceed 75% of the measured resistance of an equivalent length of the conductor.
- ii) The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Repair Sleeve for ACSR Moose Conductor shall be as per the table given below:

S.No.	Description	Unit	Particulars/ Value
1.	Material		Aluminium of minimum purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
i)	Inside diameter	mm	34.00 ± 0.5
ii)	Outside diameter	mm	54.00 ± 1.0
iii)	Length	mm	300.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		
i)	Outside dimension(Corner to corner)	mm	53.00 ± 0.5
ii)	Outside dimension (face to face)	mm	46.00 ± 0.5
iii)	Length	mm	330.00(Approx.)
4.	Minimum Corona Extinction voltage kV (rms) under dry condition	kV	320
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

7.5.14 VIBRATION DAMPERS FOR CONDUCTOR

- i) The vibration dampers shall be of 4R stock-bridge type with four (4) different frequencies spread within the specified aeolian frequency band width corresponding to wind speed of 1m/s to 7 m/s used at all suspension and tension points on each conductor in each and every span alongwith bundle spacers to damp out the aeolian vibrations of the conductors to the level specified hereinafter.
- ii) The clamp of the vibration damper shall be made of high strength Aluminium alloy of type LM-6. It shall be capable of supporting the damper during installation and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have sufficient grip to maintain the damper in position on the conductor without damaging the strands or causing premature fatigue failure to the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free of projections, grit or other materials which could cause damage to the conductor when the clamp is installed.

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Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of the threads or loosening during service.

- iii) The messenger cable of the damper shall be made of high strength steel with a minimum strength of 136 Kg/ sq. mm. It shall be preformed and post-formed quality in order to prevent subsequent drop of weight in service and to maintain consistent flexural stiffness of the cable while in service. The number of strands in the messenger cable shall be 19. The messenger cable shall be suitably and effectively sealed to prevent corrosion.
- iv) The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkages, inclusions and blow holes etc. The inside and outside surfaces of the damper masses shall be smooth.
- v) The damper assembly shall be electrically conductive to reduce radio interference.
- vi) The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the design torque without shearing or damaging of bolts, nuts or cap screws.
- vii) One damper minimum on each side per sub-conductor for suspension points and two dampers minimum on each side per sub-conductor for tension points shall be used for ruling design span of 400 metres.
- viii) The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.
- ix) The vibration analysis report of the system, with and without damper shall be submitted by the Bidder along with the bid. The technical particulars for vibration analysis and damping design of the system are as follows:

S. No.	Description	Technical Particulars of 400 kV Transmission line
1.	Configuration	Double ACSR Moose conductor per phase in horizontal configuration.
2.	Ruling Span length in meters	400 meters
3.	Nature of terrain	Plain with cultivated fields/Hilly terrain/Sand-dunes
4.	Suspension clamps	Armour grip suspension clamp
5.	Maximum wind load (Kg/sq.m)	75 acting on full projected area of single conductor.
6.	Max. permissible dynamic strains (microstrains)	±150

- x) The bidder shall recommend the number of vibration dampers of the type offered and their points of fixation for spans ranging from 100M to 1000 Meters in steps of 100 metres. The placement charts should be dully supported with relevant technical documents and sample calculations.
- xi) The damper placement charts shall include the following:-
 - a) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.
 - b) Placement distances clearly identifying the extremities between which the distances are to be measured.
 - c) Placement recommendation depending upon type of suspension clamps (viz Free centre type/ Armour grip type etc.)
 - d) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.
- xii) The vibration damper shall not have magnetic power loss more then 1 Watt at 600 Amps. 50 Hz. alternative current per sub-conductor when installed on a twin bundle system.

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The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Vibration Damper for ACSR Moose Conductor shall be as per the table given below:

S.No.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hot dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	KN	5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	KN	2.5
	(b) After fatigue test	KN	2
7.	Resonance frequencies range	Hz	5 to 40
8.	Maximum magnetic power loss per vibration damper watts for 600 amps, 50 Hz Alternating Current	Watts	1
9.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
10.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000
11.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
12.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)

7.5.15 BUNDLE SPACERS (LINE SPACERS) AND JUMPER SPACERS (RIGID SPACER)

- i) Armour grip bundle spacers shall be used to maintain the intra phase spacing of 450 mm between sub conductors of each bundle under all normal working conditions. The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors. The placement chart shall be provided for spans ranging from 100M to 1000 M, with the longitudinal spacing recommended for the spacers offered by them for giving the best possible performance. The number of spacers recommended for a ruling design span of 400m shall however be seven with no sub-span greater than 70m and no end sub-span longer than 40m. The bidder shall also furnish all the relevant technical documents in support of their placement chart along with the bid.
- ii) Jumpers at tension points are also to be fitted with spacers so as to limit the length of free conductor to 3.65 M and to maintain the bundle (sub-conductor) spacing of 450 mm. The bidder shall quote for rigid spacer for the jumper. Spacers for jumpers shall meet all the requirements of spacers used along with line except for its performance for vibration movement. Spacers requiring retaining rods shall not be quoted for jumpers.
- iii) The spacers offered by the bidder shall satisfy the following requirements:
 - a) Spacers shall restore normal spacing of the sub conductors after displacement due to wind, electromagnetic and electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation/damage either to the conductor or the assemblies themselves. They shall maintain an uniform firm grip on the conductors. They shall also have long life without being subject to fatigue or wear.
 - b) They shall preferably be of one piece construction and shall not have separate small components. All fasteners used, if any, shall be captive and need not be removed in order to fit the spacer to the sub conductor.

- c) For spacers requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength special, Aluminium alloy of type 6061/65032 having minimum tensile strength of 35 Kg./ sq.mm. The ends of retaining rods should be properly terminated. (Parrot bill ball ended). The retaining rods (Armour rods) shall be of preformed type. The rods should be heat treated to achieve specified mechanical properties and give proper resilience and retain the same during service. The dimensions shall generally be as under:

- i) Length of each rod : 1100+15 mm
- ii) Min. Diameter of each rod : 7.87 ± 0.1 mm

The conductivity of the rods shall be not less than 40% of IACS (International Annealed Copper Standards). Direction of lay shall preferably be of right hand. Number of rods in the set shall be 8 Nos. (4 Nos. for each clamp). The centre line of the rod shall be suitably marked for ease of installation.

- d) Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert shall be forged from Aluminium alloy of type 6061/65032. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. Elastomer insert for bundle spacer shall be resistant to the effect of temperature upto 85° C.
- e) Any nut used, shall be locked in an approved manner against loosening caused by vibrations. The ends of bolts and nuts shall be properly rounded off for specified corona performance or suitably shielded.
- f) Nut cracker, hinged open and / or bolt-less type clamps are acceptable provided adequate grip can be maintained on the conductor. Designs requiring clamping bolt cap screw lock pin shall utilise a single captive fastener.
- g) Clamp with cap shall be designed to prevent its cap from slipping out of position when tightened.
- h) The clamp grooves shall be in uniform contact with the conductor over the entire clamping surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, dirt or other material, which may cause damage to the conductor when the clamp is installed.
- i) Universal type bolted clamps, covering a range of conductor sizes will not be permitted.
- j) No rubbing, other than that of the conductor clamp hinges or clamp swing bolts, shall take place between any part of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them. Relative movement of the conductors shall be without friction.
- k) The spacers shall be suitably designed that the same are flexible enough so as to avoid distortion or damage to the conductor or to themselves. Rigid spacers are acceptable only for jumpers.
- l) The spacer shall not damage or chafe the conductor in any way which might affect its mechanical strength and fatigue strength or corona performance. The spacer clamp shall not damage the conductor under any condition.
- m) The spacer assembly shall not have any projections, cuts, abrasions etc., or chattering parts which might cause corona.
- n) The material used in the spacer shall be corrosion resistant. The spacer shall be made of aluminium alloy of type 6061/65032. If fasteners of ferrous material are used, they shall be galvanised and conforming to relevant Indian Standards and shall have magnetic power loss of not more than one watt at 600 Amps. 50 Hz. alternating current, per sub-conductor.

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The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

- o) Elastomer, if used, shall be resistant to the effects of ozone, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service, at temperatures upto 85 deg. C. It shall have good fatigue resistant characteristics. The physical properties of the elastomer shall be of approved standard.
- p) The spacer assembly shall have electrical continuity. The electrical resistance between the sub conductor across the assembly, in case of spacer having elastomer clamp grooves, shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions.
- q) The spacer assembly shall be easy in installation/removal and reinstallation without any damage.
- r) The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.
- s) The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hour to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.
- t) For the spacer involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation.
- u) No rubbing, other than that of conductor clamp hinges or clamp swing bolts, shall take place between any parts of the spacer. Joint incorporating a flexible medium shall be such that there is no relative slip between them.
- v) The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Bundle Spacer for Twin ACSR Moose Conductor shall be as per the table given below:

S.No	Description	Unit	Particulars/ Value		
1.	Type of Bundle Spacer		Armour grip type		
2.			<u>Insert</u>	<u>Main body</u>	<u>Retaining rods (if any)</u>
(i)	Materials of components		Aluminum alloy 6061/ 65032	Tube Aluminum alloy 6063/ 63400; 6061/ 65032	Aluminum alloy 6061 /65032
(ii)	Manufacturing process of component parts		Forged	Tube-extrusion	Heat treatment during manufacturing
3.	Retaining rods (if used)				
	(a) Number of retaining rods used for each spacer	no.	8		
	(b) Diameter	mm	7.87 ± 0.1		
	(c) Length	mm	1100+15		
4.	Elastomer				
	(a) Type		Chloroprene/Neoprene		
	(c) Moulded on insert		Yes		
	(d) Shore hardness		65 to 80		

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	(e) Thickness on insert	mm	5(Average)
	(f) Temp. range for which designed	°C	95
5.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7
6.	Slipping strength of spacer clamp		
	a) Before vibration test	KN	2.5
	b) After vibration test	KN	2
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
8.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro volts	1000

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Rigid Spacer for Twin ACSR Moose Conductor shall be as per the table given below:

S.No.	Description	Unit	Particulars/ Value
1.	Type of Spacer		Rigid type without retaining rods
2.	Material of component parts		
	(a) Clamp		Aluminum alloy (4600)
	(b) Main body		Aluminum alloy 6063/63400
3.	Manufacturing process of component parts		
	(a) Clamp		Die-casting
	(b) Main body		Aluminum extrusion
4.	Minimum ultimate tensile strength of spacer		
	(a) Compressive load	kN	14
	(b) Tensile load	kN	7.0
5.	Slipping strength of spacer clamp	kN	2.5
6.	Maximum Magnetic power loss per spacer for 600 Amps, 50 Hz Alternating Current	Watts	1
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	320
8.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro volts	1000

7.5.16 POWER CONNECTORS

- i) Power connectors of compression type shall be used for jumper connection and shall be suitable for ACSR Moose conductor for 400 kV transmission line to be used at angle Tower for transposition of the line maintaining the specified clearance and shielding. Power connectors shall conform to IS: 5561 with latest amendments. It shall be manufactured out of 99.5% pure Aluminium and shall be strong enough to withstand normal working loads. The power connector shall have a resistance across jumper less than 75% resistance of equivalent length of conductor. The power connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN tensile load. Leg sleeve of power connector should be kept at an angle of 15 deg, from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions and dimensional tolerances of power connector shall be as per table given in clause No. 7.5.13(ii).
- ii) The power connectors should be so designed and propositioned that they are capable of withstand safely normal working loads/stresses to which they may be subjected (excluding those due to short circuit and climatic conditions) so that the effect of vibration both on the conductor and the connector itself are minimised.
- iii) The power connector shall be smooth and free from cavities, blow holes and other defects and such adverse effect like sharp radii of curvature, ridges and excrescence which might lead to localised pressure or damage to conductor in service.

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- iv) Sufficient contact pressure should be maintained at the joint by the provision of the required number of bolts or other fixing arrangements, but the contact pressure should not be so great as to cause relaxation of the joint by cold flow. The joint should be such that the pressure is maintained within the range under all conditions of service. To avoid excessive local pressure, the contact pressure should be evenly distributed by the use of pressure plates, washers or suitable saddle of adequate arc and thickness.
- v) The rated current, frequency and short time current for one second of the power connectors shall be 1600 Amps., 50 Hz. and 40 kA respectively.
- vi) The temperature rise of power connectors above a reference ambient temperature of 40 deg. C when carrying rated current shall not exceed 45 deg. C.
- vii) All materials used shall conform to the relevant Indian Standard.
- viii) All parts of power connectors shall either be inherently resistant to atmospheric corrosion or be suitably protected against corrosion both during storage and in service.
- ix) All ferrous metal parts intended for outdoor use, except those made of stainless steel shall be protected by hot dip galvanising in accordance with IS: 2633.
- x) The threads of nuts and tapped holes shall be cut after galvanising and shall be well oiled or greased. All other threads shall be cut before galvanising.
- xi) The connectors shall be indelibly marked with rated current or any identifying mark to enable full particulars of the connectors to be obtained.
- xii) Power Connectors may also be marked with ISI certification mark.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of power connector for ACSR Moose Conductor shall be as per the table given below:

S.No	Description	Unit	Particulars/ Value
1.	Material		Aluminium of purity 99.5%
2.	Dimension of Aluminum sleeve Before compression		
	i) Inside diameter	mm	34.00 ± 0.5
	ii) Outside diameter	mm	54.00 ± 1.0
	iii) Length	mm	400.00 ± 5.0
3.	Dimensions of Aluminum Sleeve after compression		
	i) Outside dimension(Corner to corner)	mm	53.00 ± 0.5
	ii) Outside dimension (face to face)	mm	46.00 ± 0.5
4.	Axial tensile strength of welded portion of Power connector	KN	30
5.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75
6.	Minimum Corona Extinction voltage kV (rms) under dry condition	kV	320
7.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 305 kV (rms) under dry condition	Micro Volts	1000

7.5.17 BALANCING WEIGHTS

For holding the single suspension pilot insulator string, used for jumper connections at the transposition towers from excessive deflection., suitable balancing weights are to be suspended, which shall be made of cast iron/machined mild steel hot dipped galvanised and consist of four weights weighing 50 Kg. each. The balancing weights shall be connected to the line side yoke plate of pilot suspension string by means of eye bolt and shackle arrangement. The bottom weight shall be provided with recess to shield the ends of eye bolts. The same shall be suitable for use on 400 kV transmission lines.

7.5.18 MID SPAN COMPRESSION JOINT FOR EARTH WIRE

- i) The mid-span compression joint for earth wire shall be used for joining of two lengths of Galvanised Steel Stranded (GSS) Earth wire of size 7/3.66 mm for 400 kV lines.
- ii) The joint sleeve shall be made of mild steel with aluminium encasing. The steel sleeve should not crack or fail during compression. The Brinell Hardness of steel should not exceed 200. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than 99.5%. Filler aluminium sleeve shall also be provided at the both ends. The joints shall not permit slipping off, damage to, or failure of the complete earth wire or any part thereof at a load less than 95% of the ultimate tensile strength of the earth wire. The joint shall have resistivity less than 75% of resistivity of an equivalent length of Earth wire. The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Mid span compression Joint for 7/3.66 mm GS Earthwire shall be as per the table given below:

S.No	Description	Unit	Particulars/ Value		
			Aluminium / Filler Sleeve	Steel Sleeve	
1.	Material of Joint		Aluminium (minimum purity 99.5%)	Mild Steel (Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200		
3.	Dimension of sleeve Before compression		Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	11.50 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	32.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	400 ± 5	230 ± 5	60 ± 5
4.	Dimensions of Sleeve after compression				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
iii)	Length	mm	430 (approx)	265 (approx)	
5.	Slip strength	KN	65		
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m2	600		
b)	Purity of Zinc used for galvanising	%	99.95		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	6 dips of 1 minute		

7.5.19 FLEXIBLE COPPER BOND FOR EARTHWIRE

The flexible copper bond shall be circular in cross -section of minimum 34 sq. mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as 7 stranded ropes, each of 37 bunched wires. Two tinned copper connecting lugs shall be press jointed to the either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16mm dia. bolt. The complete assembly shall also include one 16 mm dia 40 mm long HRH M.S. bolt hot dip galvanised, with nut and lock washer. The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Flexible Copper Bond for for 7/3.66 mm GS Earthwire shall be as per the table given below:

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S.No	Description	Unit	Particulars/ Value
1.	Stranding		37/7/0.417
2.	Cross sectional area	Sq.mm	35.4
3.	Minimum copper equivalent area	Sq.mm	34
4.	Length of copper cable	mm	500 + 5
5.	Material of lugs		Tinned copper
6.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40
7.	Slip Strength	kN	3

7.5.20 REPAIR SLEEVES FOR EARTH WIRE

- i) These should be designed to make good a earth wire, of which not more than 1/6th of the strands in the outer layer have been severed.
- ii) These shall be of the compression type.
- iii) The breaking load test on repair sleeve suitable for earth wire 7/3.66 mm shall be carried out in the manner as the breaking load test on conductor repair sleeves of IS:2121 with latest amended or equivalent/better standard except for the fact that the conductor shall be replaced by earth wire.
- iv) The repair sleeves for earth wire shall also be subjected to galvanising test as per IS: 2633 with latest amended. (Methods for testing uniformity of coating on zinc coated articles). The coating requirement is 300 g/m² as amount of coating and 3 dips each of 1 minute for uniformity of coating.
- v) These should be packed to bear stresses of transportation.

7.5.21 VIBRATION DAMPER FOR EARTH WIRE

- i) These dampers are required as Stock Bridge vibration damper 'suitable for 7/3.66 mm earth wire '4R' type with four (4) different frequencies spread within the specified aeolian frequency band width corresponding to wind speed of 5 m/s to 7 m/s which shall be used at all suspension and tension points on each overhead earth wire in each span to damp out aeolian vibrations of the earth wire to the specified level as stated here-in-after.
- ii) The clamp of the vibration damper shall be made of aluminium alloy. It shall be capable of supporting the damper during installation and prevent damage or chafing of the earth wire during erection or continued operation. The clamp shall have smooth and permanent grip to keep/maintain the damper in position on the earth wire without damaging the strands or causing premature fatigue failure of the earth wire under the clamp. The clamp groove shall be in uniform contact with the earth wire over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp shall be smooth, free of projections, grit or other materials which could cause damage to the earth wire when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of the threads or loosening during service.
- iii) The messenger cable of the damper shall be made of high strength galvanised steel /stainless steel with a minimum strength of 136 Kg/sq.mm. It shall be preformed and post formed quality in order to prevent subsequent drop of weight in service and to maintain consistent flexural stiffness of the cable while in service. The number of strands in the messenger cable shall be 19. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion.
- iv) The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkages, inclusions and blow holes etc.. The inside and outside surfaces of the damper masses shall be smooth.

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- v) The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the earth wire at the designed torque without shearing or damaging of bolts, nuts or cap screws.
- vi) The vibration analysis report of the system, with and without damper shall be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows:

S. No.	Description	Technical particulars of 400 kV line
1.	Configuration	One galvanised steel earth wire and one OPGW in horizontal configuration.
2.	Rulling span length in metres	400 metres
3.	Nature of terrain	Plain with cultivated fields
4.	Maximum wind load (Kg/sq.mm)	As per Sag Tension calculation
5.	Max. permissible dynamic strains (micro strains)	± 150

- vii) The bidder shall recommend the number of vibration dampers of the type offered and their points of fixation for spans of 100m, and up to 1100 meters in steps of 100 meters. All the placement charts should be dully supported with relevant technical documents and sample calculations.
- viii) One damper minimum on each side per earth wire at suspension points and two dampers on each side per earth wire at tension points shall be used for ruling design span of 400 meters for 400 kV line.
- ix) The damper placement charts shall include the following:-
- Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per earthwire span.
 - Placement distances clearly identifying the extremities between which the distances are to be measured.
 - Placement recommendation depending upon type of suspension clamps (viz free centre type/ trunion type etc.)
 - The influence of mid span compression joints in the placement of dampers.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Vibration Damper for 7/3.66 mm GS Earthwire shall be as per the table given below:

S.No.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/mild steel/Zinc alloy duly hot dip galvanised
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm ²	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that. before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power	%	+/-40 (Maximum)

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	dissipation after fatigue test in comparison with that before fatigue test		
10.	Galvanising		
	a) Minimum weight of Zinc coating for steel parts	gm/m ²	600
	b) Purity of Zinc used for galvanising	%	99.95
	c) Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

7.5.22 SUSPENSION CLAMPS FOR EARTH WIRE:

- i) Standard anchor shackle/twisted shackle for earthwire suspension clamp shall be suitable for attaching to the hanger plate of tower.
- ii) Suspension clamps shall be used for suspending earth wire at all suspension towers and shall be suitable for supporting the GSS earth wire of size 7/3.66 mm for 400 kV lines.
- iii) The suspension clamps shall conform to the latest version of IS: 2486 and shall have adequate area of support for the earth wire. The groove of the clamp shall be smooth, finished in an uniform circular or oval shape and shall slope downwards in a smooth curve to avoid edge support and hence to reduce the intensity of bending moment on the earth wire.
- iv) There shall be no sharp points in the clamps coming in contact with earth wire. There shall not be any displacement in the configuration of the earth wire strands nor shall the strands be unduly stressed in final assembly.
- v) The clamping piece and the clamp body shall be clamped by at-least two 'U' bolts of size not less than 10mm diameter having one nut and one 3 mm thick lock nut with washers on each of its limbs. Suspension clamps shall be provided with inverted type of 'U' bolts. One limb of the 'U' bolt shall be long enough to accommodate the lug of the flexible copper bond.
- vi) The contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pin etc.. The total drop of the suspension assembly from the centre point of the attachment to the centre point of the earthwire shall not exceed 150mm. The design of the assembly shall be such that the direction of run of the earthwire shall be same as that of the conductor.
- vii) The suspension clamp shall be "envelope" type or trunion type.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Suspension Clamp for 7/3.66 mm GS Earthwire shall be as per the table given below:

S.No	Description	Unit	Particulars/ Value
1.	Material of components		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI / Al Alloy 4600
	(c) U- Bolt		Mild Steel
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25
4.	Slipping Strength	kN	12 to 17
5.	Galvanising		
	a) Minimum weight of Zinc coating for steel parts	gm/m ²	600
	b) Purity of Zinc used for galvanising	%	99.95
	c) Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute c) all others: 6 dips of 1 minute

7.5.23 TENSION CLAMPS FOR EARTH WIRE

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- i) Suitable compression type tension clamps shall be used at all tension towers for holding/anchoring the 7/3.66 mm galvanised steel earth wire for 400 kV lines. The assembly shall comprise of compression type tension clamp and two 'D' shackles. The tension clamp shall be attached to the horizontal strain plate of the tower body by means of the 'D' shackle.
- ii) These clamps shall have adequate area of bearing surface to ensure positive electrical and mechanical contact and shall not permit any slip to the earth wire under normal working tension and vibration conditions. The angle of jumper terminal to be mounted should be 30 deg. with respect to the vertical line.
- iii) The complete tension Hardware assembly shall be so designed as to avoid undue bending in any part of the clamp and shall not produce any hindrance to the movement of the clamp in horizontal and vertical direction.
- iv) The slip strength of tension clamp assembly shall not be less than 95% of the ultimate strength of the earth wire. The ultimate strength of the clamp and individual components shall not be less than that of earth wire.
- v) The clamps shall be complete with all the components including anchor shackle , bolts, nuts, washers, split pin, jumper arrangement etc.
- vi) The clamps shall be made of mild steel with Aluminium en-casing. The steel should not crack or fail during compression. The Brinnel hardness of steel sleeve shall not exceed 200. The steel sleeve shall be hot dip galvanised. The Aluminium encasing shall have Aluminium of purity not less than 99.5% . Filler Aluminium sleeve shall also be provided at the end.

The guaranteed technical particulars to be adhered by the contractor/ manufacturer of Tension Clamp for 7/3.66 mm GS Earthwire shall be as per the table given below:

S.No	Description	Unit	Particulars/ Value		
1.	Material of components				
	(i) Anchor Shackle		Forged Steel		
	(ii) Compression Clamp				
	a) Steel Sleeve		Mild Steel		
	b) Aluminium sleeve		Aluminium of purity 99.5%		
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%		
2	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	120-200		
3.	Dimension of sleeve Before compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	<u>Alu filler sleeve</u>
	i) Inside diameter	Mm	22.00 ± 0.5	11.50 ± 0.2	11.50 ±0.2
	ii) Outside diameter	Mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
	iii) Length	Mm	245 ± 5	205 ± 5	25 .0
4.	Dimensions of Sleeve after compression				
			<u>Aluminium Sleeve</u>	<u>Steel Sleeve</u>	
	i) Outside dimension(Corner to Corner)	Mm	29.40 ± 0.5	20.20 ± 0.5	
	ii) Outside dimension (face to face)	Mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	65		
6.	Minimum Breaking strength of assembly (excluding clamp)	KN	70		
7..	Compression Pressure	Ton	100		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m ²	600		
b)	Purity of Zinc used for galvanising	%	99.95		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand.	Nos.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute		

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		c) all others: 6 dips of 1 minute
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7.5.24 MATERIAL, DESIGN AND WORKMANSHIP

DETAILS OF MATERIAL

S. No.	Name of Item	Material	Process of Treatment	Reference Standard	Remarks
1.	Security Clips	Stainless Steel/ Phosphor Bronze	-	AISI 302 or 304-L/IS-1385	
2.	Arcing Horn	Mild Steel Rod/ Tube type	Hot dip galvanised	As per IS-226 or IS-2062	
3.	Ball fittings, Socket, All shackles links cleves,	Class-IV steel	Drop forged and normalised Hot dip galvanised	As per IS2004	
4.	Yoke Plate	Mild Steel	Hot dip galvanised	As per IS226/IS-2062	
5.	Sag Adjustment Plate	Mild Steel	Hot dip galvanised	As per IS226/IS-2062	
6.	(a) Corona control ring/grading ring	High Strength Al. Alloy tube (6061/6063/1100 type or 65032/63400 type)	Heat treated	ASTM-B429 or as per IS	Mech. strength of welded joint shall not be less than 20 KN
	(b) Supporting Brackets and Mounting Bolts	High Strength Al. alloy 6061/6063/1100/ 65032/63400 type or Mild steel	Heat treated Hot dip galvanised	ASTM-B429 or as per IS:226 or IS-2062	
7.	Free centre clamp/ Envelope type Clamp				
	(a) Clamp body/Keeper Piece	High Strength Al. Alloy 4600/LM-6 or 6061/65032	Casted or forged and Heat treated	IS:617 or ASTM-B429	
	(b) Cotter bolts, Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	IS-226	
	(c) U Bolts	Stainless steel or High Strength Al. alloy 6061/6063 or 65032/63400	Forged & heat treated	AISI 302 or 304-L ASTM- B429	
8.	Dead End Assembly				
	(a) Outer Sleeve (of dead end assembly for ACSR 'Moose' conductor)	EC grade Al. of purity not less than 99.5%.			
	(b) Steel Sleeve	Mild Steel	Hot Dip galvanised	As per IS:226	
9.	Turn Buckle	Class II Steel	Forged Hot Dip Galvanised	As per IS:2004	
10.	P.A.Rod	High Strength AL alloy type 6061/65032	Heat treatment during manufacturing	ASTM-B429	Min tensile strength of 35 kg/mm ²
11.	AGS Clamp a) Supporting House	High Strength Corrosion resistant AL. Alloy LM6, 4600 or 6061/65032	Cast/Forged Heat treated	ASTM-B429 or as per IS	
	b) AL. Insert & Retaining Strap	High Strength AL alloy type 6061/65032	Forged Heat treated	ASTM-B429 or as per IS	
	c) Elastomer Cushion	Moulded on AL. reinforcement			
12.	Balancing Weights	Cast Iron/MCI/Mach. Steel	Hot Dip Galvanised Mild		

7.5.24.1 GENERAL

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- i) All the equipment shall be of the latest proven design and shall conform to the best modern engineering practice adopted in the field of extra high voltage engineering. The bidder shall offer only such equipment as are guaranteed by him to be satisfactory and suitable for 400 kV transmission lines application with bundle conductors and will give continued good performance.
- ii) The design, manufacturing process and quality control of all the materials shall be such as to provide/achieve requisite factor of safety for maximum working load, highest mobility, elimination of sharp edges and corners to limit corona and radio interference, best resistance to corrosion and a good finish.
- iii) The fasteners shall conform to the requirements of IS: 6639. All fasteners and clamps shall have suitable corona free locking arrangement to guard against vibration loosening.
- iv) Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process.. Welds shall be clean, sound, smooth uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids, incomplete penetration, incomplete fusions, undercutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.
- v) Particular care shall be taken during manufacture and subsequent handling to ensure smooth surface free from abrasion or cuts.

7.5.24.2 GALVANISING

- i) All ferrous parts including steel components, bolts, nuts and washers etc., shall be hot dip galvanised after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanised as per grade 4 of IS: 1573. The bolt threads shall be undercut to take care of increase in diameter due to galvanising. Galvanising shall be done in accordance with IS: 2629/IS: 1367(Part-13) and shall satisfy the tests mentioned in IS:2633. Bolts, nuts and washers shall withstand four dips while spring washers shall withstand three dips. Other galvanised materials shall be guaranteed to withstand at least six dips each lasting one minute under the standard Preece test for galvanising unless otherwise specified.
- ii) The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from all imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The zinc used for galvanising shall be of grade Zn 99.95 as per IS:209. Minimum weight of zinc coating shall be 300 g/sq.m. and thickness 43 micron and minimum average mass of coating 375 g/sq.m and thickness 54 micron for fasteners and 600 g/sq.m. for all other hot dip galvanised articles.
- iii) Hot dipped galvanised fasteners shall withstand four dips in the standard preece test while electroplated spring washers shall have zinc coating of grade.4 (reference clause 3.2 of IS:1573 appendix A) i.e. local thickness min. 25 micron and average thickness 38 micron. Other galvanised material shall withstand minimum six dips each of one minute duration in the standard Preece test.

7.5.24.3 CASTINGS

- i) All ferrous and Aluminium alloy castings, shall be free of all internal defects like shrinkages, inclusions, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.
- ii) All castings shall be smoothly and evenly finished by machining, buffing etc., so as to eliminate sharp ends, edges, abrasions and projections. No surface area of the accessories and Hardwares in contact with the conductors shall cause damage to the conductors in any manner either during erection or during continuous operation. The surfaces in contact with the conductor shall not cause any abnormal electrical or mechanical stresses during normal working and operating conditions.

7.5.24.4 CURRENT CARRYING PARTS

- i) All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum and localised heating phenomenon is averted.
- ii) The design of metal parts and their mating surfaces in contact with conductors shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under all operating conditions.

7.5.24.5 METAL PARTS OF EARTH WIRE HARDWARE

- i) The suspension clamp shall be of malleable cast iron or forged steel or of aluminium alloy. The tension clamp shall be made of stainless steel conforming to BS: 970 EN 58 A grade or equivalent thereof.
- ii) 'D' shackles, cleaves 'U' bolts, cotter pins and other components shall be manufactured from drop forged steel conforming to IS: 2004 or equivalent thereof.
- iii) Bolts, nuts and washers shall be as per IS: 1367 and shall be of reputed make.
- iv) All split pins shall be of stainless steel.

7.5.24.6 COMPRESSION MARKINGS

- i) Die compression areas shall be clearly marked on each component which are to be pressure compressed such as midspan compression joints and tension Hardwares.

The marking shall be an etched inscription with the words 'COMPRESS FIRST' on components which are meant for continuous die compression. Where components are designed for intermittent die compressions, the compression and non-compression zones shall bear etched inscription such as 'COMPRESSION ZONE' and "NON COMPRESSION ZONE" distinctly with etched arrow signs indicating the direction of compression and knurled marks showing the end of the zones.

- ii) All inscriptions etched on metal shall be distinct, legible and shall not wear out in the course of normal handling.

7.5.24.7 FORGED COMPONENTS

- i) Forged components other than those covered in the clauses mentioned herein above shall be made out of class IV steel as per IS: 2004 or equivalent.

The items shall be normalised to achieve the required tensile properties. The forged components shall not have sharp corners and edges so as to affect corona and RIV performance.

7.6 TESTS & STANDARDS

7.6.1 TESTS

The following acceptance and routine tests and tests during manufacture shall be carried out on the material. The certificates for the type tests as listed below are required to be furnished. For the purpose of this Clause:-

- 7.6.1.1 Type tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this specification. The test reports for these tests shall be furnished by the contractors as per the requirement of clause no. 1.1 "Technical Evaluation " of section 3, EQC.(Vol I)

- 7.6.1.2 Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-despatch inspection, for the purposes of acceptance of that lot.

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- 7.6.1.3 Routine tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.
- 7.6.1.4 Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Supplier to ensure the desired quality of the end product to be supplied by him.
- 7.6.1.5 The norms and procedure of sampling for these tests will be as per relevant standards / Quality Assurance programme.
- 7.6.1.6 The Standards and norms to which these tests will be carried out are listed against them. Where a particular test is a specific requirement of this specification, the norms and procedure of the test shall be as specified in Annexure-A or as mutually agreed to between the Supplier/contractor and the Employer in the Quality Assurance programme.
- 7.6.1.7 For all type and acceptance tests, the acceptance values shall be the values specified in this specification or guaranteed by the Bidder, as applicable.

7.7 TYPE TESTS

The following shall constitute the Type tests.

7.7.1. ON THE COMPLETE INSULATOR STRING WITH HARDWARE FITTINGS.

a.	Power frequency voltage withstand test with corona control rings/grading ring and arcing horn under wet condition	IEC:383
b.	Switching surge voltage withstand test under wet condition.	IEC: 383
c.	Impulse voltage withstand test under dry condition	IEC: 383
d.	Impulse voltage flashover test under dry condition	IEC: 383
e.	Voltage distribution test(on disc insulators string)	Annexure-A
f.	Corona and RIV test under dry condition	
g.	Mechanical strength test	Annexure -A
h.	Vibration test	Annexure -A

Note: For electrical tests, the insulator shall be mounted on a simulated tower.

7.7.2 ON SUSPENSION HARDWARE FITTINGS ONLY.

a.	Clamp slip strength for AGS clamp	Annexure-A
b.	Clamp slip strength Vs torque test for suspension clamp	Annexure-A
c.	Magnetic power loss test for suspension assembly	Annexure-A
d.	Ozone Test on Elastomer	Annexure-A
e.	Mechanical Strength test	Annexure-A

7.7.3 ON TENSION HARDWARE FITTINGS ONLY:

a.	Electrical resistance test for dead end assembly	IS:2486 (Part-I)
b.	Heating cycle test for dead end assembly	
c.	Slip strength test for dead end assembly	
d.	Mechanical Strength test	Annexure-A

Notes:

- The type tests given under Clause No. 7.7.1 are conducted on all the insulator strings alongwith hardware fittings. However, vibration test shall not be conducted on pilot string.
- All the type tests specified under Clause No. 7.7.2 are conducted on suspension assembly.
- All the type tests specified under Clause No. 7.7.3 are conducted on tension assembly.

7.7.4 ON ARMOUR RODS

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a.	Tensile strength test	Annexure-A
b.	Corona test	
c.	Radio interference voltage test	IS:2121 (part-I)
d.	Slip strength test	Annexure-A
e.	Bend test	
f.	Resilience test	

7.7.5 ON MID SPAN COMPRESSION JOINT FOR CONDUCTOR AND EARTH WIRE

a.	Slip strength test (Failing load test)	Annexure-A
b.	Electrical Resistance test	IS:2121(Part-II)
c.	Heating cycle test	Annexure-A
d.	Corona extinction voltage test (Dry)	Annexure-A
e.	Radio interference voltage test (Dry)	Annexure-A
f.	Galvanising test	IS:2633 & IS: 6745
g.	Chemical analysis of materials	Annexure-A

Note: Test at (c), (d) & (e) are not applicable for mid-span compression joints for earth wire.

7.7.6 ON FLEXIBLE COPPER BOND FOR EARTH WIRE

Slip strength test:

Annexure -A

7.7.7 ON VIBRATION DAMPER FOR CONDUCTOR AND EARTH WIRE

a.	Dynamic characteristics test	Annexure-A
b.	Vibration analysis	Annexure-A
c.	Clamp slip test	Annexure-A
d.	Fatigue tests	Annexure-A
e.	Galvanising test	IS:2633
f.	Magnetic power loss test	Annexure-A
g.	Corona extinction voltage test (Dry)	
h.	Radio interference voltage test dry	Annexure-A
i.	Torque test	IS:9708
j.	Determination of weight of zinc coating	IS:6745
k.	Chemical analysis test of materials	Annexure-A
l.	Damper efficiency test	IS:9708

Note: Test at (f), (g) & (h) are not applicable to damper for earth wire.

7.7.8 A) ON LINE SPACER (For Twin ACSR 'MOOSE')

a.	Vibration test	Annexure-A
	i)Vertical vibration	
	ii)Longitudinal vibration	
	iii)Sub span oscillation	
b.	Clamp slip test	Annexure-A
c.	Movement test	Annexure-A
d.	Magnetic power loss test (if applicable)	Annexure-A
e.	Fault current test/ compression -tension test	Annexure-A
f.	Corona extinction voltage test dry	Annexure-A
g.	Radio interference voltage test dry	Annexure-A
h.	Ozone Test	Annexure-A
i.	Chemical analysis of materials	Annexure-A

7.7.8 B) ON RIGID SPACER FOR JUMPER

a.	Chemical analysis of materials	Annexure -A
b.	Clamp slip test	
c.	Magnetic power loss test (if applicable)	

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d.	Tension compression test	
e.	Corona extinction voltage test dry	
f.	Radio interference voltage test dry	
g.	Galvanising test	
		IS:2633, IS: 6745 & IS:1573

7.7.9 ON SUSPENSION CLAMP ASSEMBLY FOR EARTH WIRE

a.	Slip strength test	IS:2466 Part-I Annexure-A
b.	Mechanical strength test	
c.	Galvanising test	IS:2633, IS: 6745 & IS:1573
d.	Chemical analysis of materials	Annexure-A
e.	Clamp slip strength Vs Torque test for suspension assembly	Annexure-A

7.7.10 ON TENSION CLAMP ASSEMBLY FOR EARTH WIRE

a.	Slip strength test on tension assembly	Annexure-A IS:2486 (Pt.-I)
b.	Minimum failing load test	
c.	Galvanising test	IS:2633, IS:6745 & IS:1573
d.	Chemical analysis of materials	Annexure-A
e.	Mechanical strength test (excluding clamp)	Annexure-A
f.	Electrical resistance test on tension clamp	Annexure-A

7.7.11 ON POWER CONNECTORS FOR CONDUCTOR

a.	Tensile test	IS:5561
b.	Electrical resistance test	IS:2121(Part-II)
c.	Dimensional check	IS:5561
d.	Galvanising test (where applicable)	
e.	Chemical analysis of materials	Annexure-A
f.	Heating cycle test	IS:2121-(Part-II)
g.	Corona extinction voltage test (dry)	Annexure-A
h.	Radio interference voltage test (dry)	Annexure-A
i.	Axial tensile load test for welded portion	Annexure-A

7.7.12 ON REPAIR SLEEVE FOR CONDUCTOR:

a.	Corona extinction voltage test (dry)	Annexure-A
b.	Radio interference voltage test (dry)	
c.	Chemical analysis test of materials	Annexure-A

7.8 ACCEPTANCE TESTS/SAMPLE TESTS**7.8.1 ON BOTH SUSPENSION AND TENSION HARDWARE FITTINGS:**

a.	Visual examination	IS:2486 (Part-I)
b.	Verification of dimensions	
c.	Galvanising /electroplating test	IS:2486(Part-I)
d.	Mechanical strength test of welded joint	Annexure-A
e.	Mechanical strength test for corona control rings/grading rings and arcing horns	IS:3288 (Part-I)
f.	Test on locking devices for ball and socket coupling	IEC:372
g.	Mechanical strength test of each component(excluding corona control rings/grading rings and arcing horn)	Annexure-A
h.	Chemical analysis, hardness tests, grain size, inclusion rating and magnetic particle inspection for forgings/castings	Annexure-A

7.8.2 ON SUSPENSION HARDWARE FITTINGS ONLY:

a.	Clamp slip strength Vs. torque test for suspension clamp	Annexure-A
b.	Shore hardness test of elastomer cushion for AG suspension clamp	Annexure-A
c.	Bend test for armour rods set	IS:2121 (Part-I)/ Annexure-A
d.	Resilience test for armour rods set	IS:2121 (Part-I)/ Annexure-A

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e.	Conductivity test for armour rods set	IS:2121 (Part-I)
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7.8.3 ON TENSION HARDWARE FITTINGS ONLY:

a.	Slip strength test for dead end assembly	IS:2486 (Part-I)
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7.8.4 ON ARMOUR RODS:

a.	Visual examination	IS:2121
b.	Dimensional verification	
c.	Hardness test	As per specification

7.8.5 ON MIDSPAN COMPRESSION JOINT FOR CONDUCTOR AND EARTH WIRE:

a.	Visual examination	IS:2121(Part-II)
b.	Dimensional verification	
c.	Galvanising test	IS:2633 & IS:6745
d.	Hardness test	Annexure-B
e.	Failing load test (test to be conducted after 24 hours of compression)	As per specification

7.8.6 ON REPAIR SLEEVE FOR CONDUCTOR AND EARTH WIRE :

a.	Visual examination	IS:2121(Part-II)
b.	Dimensional verification	IS:2121(Part-II)

7.8.7 ON FLEXIBLE COPPER BOND:

a.	Visual examination	IS:2121(Part-II)
b.	Dimensional verification	
c.	Slip strength test	Annexure-A

7.8.8 ON VIBRATION DAMPER FOR CONDUCTOR & EARTH WIRE:

a.	Visual examination	IS:2121(Part-II)
b.	Dimensional verification	
c.	Galvanising/electroplating test	
	i) On damper masses	Annexure-B
	ii) On messenger cable	
d.	Verification of Resonance frequencies	
e.	Clamp slip test	
f.	Clamp bolt torque test	
g.	Strength of the messenger cable	
h.	Mass pull off set	
i.	Dynamic characteristics test	

7.8.9 ON SPACER FOR CONDUCTOR/SPACER FOR JUMPER:

a.	Visual examination	IS:2121(Part-II)
b.	Dimensional verification	
c.	Galvanising test	
d.	Movement test (Except for spacers for jumpers)	Annexure-B
e.	Compressive and tensile test	Annexure-B
f.	Clamp slip test	Annexure-B
g.	Clamp bolt torque test	Annexure-B
h.	Assembly test for Neoprene	As per Specification
i.	UTS of retaining rod (if applicable)	Annexure-B
j.	Hardness test for Elastomer (if applicable)	Annexure-B
k.	Assembly torque test	Annexure-B

7.8.10 ON SUSPENSION CLAMP ASSEMBLY FOR EARTH WIRE:

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a.	Visual examination	IS: 2121(Part-II)
b.	Dimensional verification	
c.	Galvanising test	IS:2121(Part-II)
d.	Clamp slip strength test	Annexure-A
e.	Mechanical strength test on each component	Annexure-A

7.8.11 ON TENSION CLAMP ASSEMBLY FOR EARTH WIRE:

a.	Visual examination	IS: 2121(Part-II)
b.	Dimensional verification	
c.	Galvanising test	IS:2121(Part-II)
d.	Slip strength test	Annexure-A
e.	Mechanical strength test on each component (excluding clamp)	Annexure-A
f.	Hardness test	Annexure-A

7.8.12 ON POWER CONNECTORS:

a.	Visual examination and dimensional verification	IS:2121(Part-II)
b.	Axial tensile load test for welded portion	As per specification
c.	Tensile test	IS:5561
d.	Resistance test	
e.	Galvanising test (where applicable)	

7.9 ROUTINE TESTS

7.9.1 ON HARDWARE FITTINGS

a.	Visual inspection/examination	IS:2486 (Part-I)
b.	Proof Load Test	Annexure-A

7.9.2 ON CONDUCTOR AND EARTHWIRE ACCESSORIES

a.	Midspan compression joint for conductor and earth wire
b.	Repair sleeve for conductor.
c.	Vibration damper for conductor & earth wire.
d.	Suspension and tension Hardware for earth wire conductor
e.	Flexible copper bond.
f.	Armour rod for conductor.
g.	Repair sleeves for conductor.
h.	Power connectors.

7.9.3 The following common tests shall be carried out on all of the above accessories and Hardware as per relevant standard {IS: 2121(part-II)}/approved drawings.

- i) Visual examination.
- ii) Dimensional verification

7.10 TESTS DURING MANUFACTURE

ON ALL COMPONENTS AS APPLICABLE

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

7.11 TESTING EXPENSES:

Testing charges for all acceptance, routine test (s) and tests during manufacture required to be carried out as per requirement of the specification shall be in-built/included by the bidder in the

prices of material/equipments quoted by him in schedules of prices and no additional charges shall be paid by the employer on this account.

7.12 SAMPLE BATCH FOR TYPE TEST (Not Applicable)

7.13 ADDITIONAL TESTS

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

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

7.14 CO-ORDINATION FOR TESTING

The Supplier/ contractor shall have to co-ordinate testing of insulators with hardware fittings to be supplied by other Supplier and shall have to guarantee overall satisfactory performance of the insulators with the hardware fittings.

7.15 GUARANTEE

The contractor shall guarantee overall satisfactory performance of the insulators with the hardware fittings.

7.16 INSPECTION

7.16.1 The employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where materials shall be manufactured and representative shall have full facilities for unrestricted inspection of the contractor's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

7.16.2 The Contractor shall keep the employer informed in advance of the time of starting and of the progress of manufacture of materials in its various stages.

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

7.16.4 The acceptance of any quantity of material shall in no way relieve the contractor of any of his responsibilities for meeting all requirements of the specification, and shall not prevent subsequent rejection if such material is later found to be defective.

7.17 TYPE TEST CERTIFICATES/REPORTS

7.17.1 The Bidder must furnish certified photocopies of all the type test certificates/reports for the tests specified in the latest editions of relevant IS as per requirement of clause no. 1.1 "Technical Evaluation " of section 3 of EQC.(Vol I). The drawing number of the samples on which type tests were conducted should be clearly stated in the test report.

7.17.2 Record of routine test reports shall be maintained by the supplier at his works for periodic inspection by the employer's representative.

- 7.17.3 Test Certificates of tests carried out during manufacture shall also be maintained by the contractor. These certificates shall be produced for verification as and when desired by the employer.

7.18 TESTING FACILITIES

The bidder must indicate clearly about the various testing facilities for routine/ acceptance tests as per relevant ISS/IEC in respect of disc insulator, insulator strings & hardwares and accessories available at the works of his supplier. In case no testing facilities are available at the works of their supplier, particulars of the place where such testing is proposed to be conducted during the course of inspection must be indicated.

7.19 SCALE OF SAMPLING AND CRITERIA FOR CONFORMITY

The scale of sampling and criteria for conformity shall be as per Approved Standard Manufacturing Quality Plan.

7.20 QUALITY ASSURANCE PLAN

- 7.20.1 The Bidder shall invariably furnish following information along with his offer, failing which the offer shall be liable for rejection. Information shall be separately given for individual type of accessories offered.

- i) Statement giving list of important raw materials, name of sub-suppliers for the raw material, list of standards according to which the raw materials are tested, list of tests normally carried out on raw materials in the presence of supplier's representative, and copies of test certificates.
- ii) Information and copies of test certificates as in (i) above in respect of bought out items.
- iii) List of manufacturing facilities available.
- iv) Level of automation achieved and list of areas where manual processing exists.
- v) List of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.
- vi) Special features provided in the product to make it maintenance free.
- vii) List of testing equipment available with the Bidder for final testing of accessories specified and test plant limitation, if any, vis-a-vis the type, special acceptance, routine tests specified in the relevant standards. These limitations shall be very clearly brought out in the schedule of deviations from specified test requirements.

7.21 QUALITY ASSURANCE DOCUMENTS

- 7.21.1 The supplier shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Assurance Programme at the time of Employer's inspection of equipment/material.
- 7.21.2 The employer or his duly authorised representatives reserves the right to carry out Quality Audit and quality surveillance of the system and procedures of the Supplier's/his vendor's Quality Management and Control Activities.

7.22 BID DRAWINGS

- 7.22.1 The bidder shall furnish detailed dimensional drawings of Hardware and line accessories and all components parts. The bidder shall furnish full description and illustrations of materials offered.
- 7.22.2 Fully dimensioned drawings of the complete insulator string Hardwares and their component parts shall show clearly the following arrangements shall be furnished in five (5) copies along

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with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

- i) Attachment of the hanger or strain plate
- ii) Suspension or dead end assembly.
- iii) Arcing horn attachment to the string as specified in clause 1.8 of this technical specification.
- iv) Yoke Plates
- v) Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke Plates.
- vi) Corona control rings/grading ring attachment to conductor and other small accessories.
- vii) Links with suitable fittings.
- viii) Details of balancing weights and arrangements for their attachment in the single suspension pilot insulator string.

7.22.3 Each drawing shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting and lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions and dimensional tolerances shall be mentioned in mm.

The drawings shall include the following:-

i)	Dimensions and dimensional tolerances
ii)	Material, fabrication details including any weld details and any specified finishes and coatings. Regarding material designations & reference of standards are to be indicated.
iii)	Catalogue No.
iv)	Marking
v)	Weight of assembly
vi)	Installation instructions.
vii)	Design installation torque for the bolt or cap screw
viii)	Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
ix)	The compression die number with recommended compression pressure
x)	All other relevant technical terminal details.

7.22.4 Placement Charts for Spacers and Dampers shall also be furnished.

7.22.5 The above drawings shall be submitted with all the details as stated above along with bid documents. After the placement of award, the contractor shall again submit the drawings in four copies to the employer for approval. After employer's approval and successfully completion of all type tests, 2 (two) sets of drawings shall be submitted to each concerned field officers and to employer.

7.22.6 After placement of award, the contractor shall submit fully dimensioned drawing .

7.23 PACKING

- i) All accessories and Hardwares shall be packed in suitable sized strong and weather resistant wooden cases/crates. The gross weight of this packing shall not normally exceed 200Kg. to avoid handling problems.
- ii) The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field

7.24 MARKINGS

Each component of Hardware/accessories shall be marked with the trade mark of the manufacturer. Marks shall be forged or stamped with a steel die before galvanising. The marks shall be distinct, durable, and conspicuous.

ANNEXURE-A

PROCEDURES FOR TESTING ON HARDWARE FITTINGS & LINE ACCESSORIES

1.0 TESTS ON COMPLETE STRING WITH HARDWARE FITTINGS

1.1 Voltage Distribution Test (For insulator string with Disc insulators)

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted in to percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings for 400 kV.

1.2 Corona Extinction Voltage Test (Dry)

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than 320 kV (rms) line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 383.

1.3 RIV Test

Under the conditions as specified at (1.2) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 305 kV (line to ground) under dry condition. The test procedure shall be in accordance with IS: 8263/IEC: 437.

1.4 Mechanical Strength Test for Complete String

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to 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 load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 Vibration Test

The suspension string shall be tested in suspension mode and tension string in tension mode itself in a laboratory span of minimum 30 metres. In the case of suspension string a load equal to 600 Kg. shall be applied along the axis of the suspension string by mean of a turn buckle. The insulator string along with Hardware fittings and two sub conductors (each tensioned at 43 KN) shall be suitably secured. The system shall be suitable to maintain constant tension on each sub conductors through-out the duration of the test. Vibration dampers shall not be used on the test span. Both the sub conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulator string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement (in mm) of vibration of conductor at the anti-node point nearest to the insulator string shall be measured and the same shall not be less than $1000/f^{1.8}$, where 'f' is the frequency of vibration in Hz. The insulator string shall be vibrated for not less than 10 million cycles without any failure.

After the test, the insulators shall be examined for looseness of pins and cap or any crack in the cement. The Hardware fittings shall be examined for looseness, fatigue and mechanical strength test. There shall be no deterioration of properties of Hardware components and disc insulators after the vibration test. The disc insulators shall be subjected to the following tests as per relevant standards:

S. No.	Tests	Percentage of insulator units to be tested	
		Disc Insulators	Long Rod Insulator
a.	Temperature cycle test followed by mechanical performance test	60	100
b.	Puncture test/steep wave front test	40	--

2.0 TESTS ON HARDWARE FITTINGS**2.1 Magnetic Power Loss test for suspension assembly**

Two hollow aluminium tubes of 32 mm diameter shall be placed 450 mm apart. An alternating current over the range of 400 to 800 amps shall be passed through each tube. The reading of the wattmeter with and without two suspension assemblies (clamps complete with all components) along with line side yoke plate, clevis eye, shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss per suspension assembly shall be plotted for each value of current. The value of the loss corresponding to 600 amps. shall be read off from the graph.

2.2 Galvanising/Electroplating Test

The test shall be carried out as per IS:2486(Part-I) except that both uniformity of Zinc coating and standard Preece test shall be carried out and the results obtained shall satisfy the requirements of this specification.

2.3 Mechanical Strength Test of Each Component

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified UTS is achieved and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

2.4 Mechanical strength Test of Welded Joint:

The welded portion of the component shall be subjected to a Load of 2000 kgs for one minute. Thereafter, it shall be subjected to die-penetration/ultrasonic test. There shall not be any crack at the welded portion.

2.5 Clamp Slip Strength Vs Torque Test for Suspension Clamp

The suspension clamp assembly shall be vertically suspended by means of a flexible attachment. A suitable length of ACSR "Moose" conductor shall be fixed in the clamp. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the conductor. The clamp slip strength vs torque curve shall be drawn. The above procedure is applicable only for free centre type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out. The clamp slip strength at the recommended tightening torque shall be more than 20KN but less than 29KN.

2.6 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between 65 to 80.

2.7 Proof Load Test

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength, which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

2.8 Tests for Forging, Casting and Fabricated Hardware

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated Hardware shall be as per the internationally recognised procedures for these tests. The sampling will be based on head number and heat treatment batch. The details regarding test will be as in the Quality Assurance Programme.

2.9 Mechanical Strength Test for Suspension/Tension Hardware Fittings

The complete string without insulators excluding arcing horn, corona control rings/grading rings and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum UTS which shall be increased at a steady rate to 67% of the minimum UTS specified. This 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 UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

2.10 Ozone Test for Elastomer

This test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2x magnification.

3.0 TESTS ON CONDUCTOR AND EARTH WIRE ACCESSORIES

3.1 Mid Span Compression Joints for Conductor and Earth Wire

a) Slip strength Test (Failing load Test)

The fitting compressed on conductor/earthwire shall not be less than one metre in length. The test shall be carried out as per IS:2121 (Part-II) except that the load shall be steadily increased to 95% of the minimum ultimate tensile strength of conductor/earth wire and retained for one minute at this load. There shall be no movement of the conductor/earth wire relative to the fittings and no failure of the fittings during this one minute period.

b) Corona extinction voltage test(dry):

The sample of the conductor accessories shall be installed on ACSR 'Moose' conductor arranged as a 5 meter long horizontal Twin bundle with 450 mm sub-conductor spacing.

The sample shall then be subjected to 50 Hz phase to earth voltage simulating the maximum surface gradient as obtained on line corresponding to 320 kV.

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 320 kV line to ground under dry conditions.

There shall be no evidence of corona on any part of the sample when all possible sources of corona are photographed in a darkened room. Corresponding corona inception voltage shall be recorded.

3.2 Power Connector For Conductor:

Axial Tensile Load for Welded Portion

The sleeve portion of the power connector shall be compressed on conductor. The compressed portion shall be held rigidly on some fixtures and axial load shall be applied alongwith the jumper terminal. The load shall be increased gradually till breaking of welded joint occurs. The breaking load should be above 30 kN.

3.3 Flexible Copper Bond For Earthwire

Slip Strength Test

On applying a pull of 3 KN between the two ends, stranded flexible copper cable shall not come out of the connecting lugs and none of its strands shall be damaged. After the test, the lugs shall be cut open to ascertain that the gripping of cable has not been affected.

3.4 Vibration Damper For Conductor and Earth Wire

a) Dynamic Characteristics Test

The damper shall be mounted with its clamp tightened at the torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 5 to 40 Hz for damper for 'Moose' conductor and 10 to 60 Hz for damper for earthwire. The damper assembly shall be vibrated vertically with ± 1 mm amplitude from 5 to 15 Hz frequency and 15Hz at ± 0.5 mm to determine the following characteristics with the help of suitable recording instruments.

- i) Force Vs frequency
- ii) Phase angle Vs frequency
- iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor/ earthwire without dampers.

Acceptance criteria for vibration damper.

- (i) The above dynamic characteristics test on five damper shall be conducted.
- (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
- (iii) The above mean reactance response curve should lie within $0.191 f$ to $0.762 f$ Kg/mm limits for ACSR 'Moose' conductor damper, and $0.060 f$ to $0.357 f$ Kg/mm limits for earthwire 7/3.15 damper where 'f' is frequency in Hz
- (iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- (v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
- (vi) Visual resonance frequencies of each mass of damper are to be recorded and to be compared with the guaranteed values.

b) Vibration Analysis

The vibration analysis of the conductor/ earthwire shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis:

- i) The analysis shall be done for a single conductor (28.62 mm) without armour rods as per the parameters for power conductor. The tension shall be taken as 44.2 KN (4500 Kg.) for power conductor and 14 KN for earthwire for a span ranging from 100 M to 1000 M.
- ii) The self damping factor and flexure stiffness (EI) for power conductor/earthwire shall be calculated on the basis of experimental results. The details of experimental analysis with these data should be furnished.
- iii) The power dissipation curve obtained from Dynamic Characteristic Test shall be used for analysis with damper.
- iv) Examination of the Aeolian vibration level of the conductor/earthwire with and without vibration damper installed at the recommended location for wind velocity ranging from 0 to 30 KM per hour, predicting amplitude, frequency and vibration energy input.
- v) From vibration analysis of conductor/ earthwire without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the aeolian vibration levels exceed the specified limits shall be determined.
- vi) From vibration analysis of conductor/earthwire with damper/ dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the conductor/ earthwire shall be determined. In addition to above damper clamp vibration amplitude and antinode vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment points, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitudes shall not be more than that of the specified fatigue limits.

c) Clamp slip and fatigue tests:

i) Test set up:

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum span length of 30 M. The ACSR 'Moose' conductor/ earthwire shall be tensioned at 44.2 KN (4500 Kg.)/14.72 KN (1500 Kg.) respectively and shall not be equipped with protective armour rods at any point . Constant tension shall be maintained within the span by means of liver arm arrangement. After the power conductor / earthwire has been tensioned, clamps shall be installed to rigidly support the conductor / earthwire at both ends, and thus influence of connecting Hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor/ earthwire. There shall be no loose parts, such as suspension clamps, U-bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for stepless speed control as well as stepless amplitude arrangement. The equipment shall be available/suitable for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

ii) Clamp slip Test:

The vibration damper shall be installed on the test span. The damper clamp, after tightening with the manufacturer's specified torque, when subjected to a longitudinal pull of 2.5 KN parallel to the axis of power conductor /earthwire for a minimum duration of one minute shall not slip i.e. the permanent displacement between conductor/earthwire and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased till the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

iii) Fatigue Test:

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement. The damper shall then be vertically vibrated sinusoidal at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than $\pm 25/f$ mm, where 'f' is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein above shall be repeated after fatigue test without retorquing or adjusting the damper clamp and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor/ earthwire and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose or damaged parts. There shall not be significant deterioration or wear of the damper. The power conductor / earthwire under the clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

- (1) There shall not be any frequency shift by more than ± 2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.
- (2) The force response curve shall generally lie within guaranteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.
- (3) The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Contractor. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

d) Magnetic power loss test:

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave A.C. The test shall be carried out at various currents ranging from 300 Amperes to 900 Amperes and the magnetic power loss at various currents shall be specified in a tabulated graphical form. The difference between the power losses without and with sample at room temperature shall be limited to 1 watt for 600 Amperes current (rms). The losses shall be determined by averaging the observations obtained from a group of at least four samples tested simultaneously.

e) Corona extinction voltage test (dry):

As per clause 3.1(b) above.

3.5 Spacer (For Twin bundle)

a) **Vibration Tests:**

The test set up shall be as per Clause No. 3.4 (c) (i) above. The sample of spacer assembly shall be clamped to conductor. During the vibration tests the axis of the clamp of sample shall be maintained parallel to its initial static position by applying a tension of 44.2 KN (4500 Kg.) on the ACSR 'Moose' conductor. The sample shall be free to vibrate and shall not be retorqued or adjusted between the tests.

All the vibration tests mentioned hereunder shall be conducted on the same sample on the same test span. The samples shall withstand the vibration tests without slipping on the conductor, loosening, damage or failure of component parts. After each vibration test, clamp slip test shall be carried out as per the procedure given in Clause No. 3.5 (b) below

i) **Longitudinal Vibration Test:**

The stationary conductor and the vibrating conductor/ equivalent diameter of aluminium alloy tube shall be restrained by fixed clamps. The displacement of the vibrating conductor shall be 25 mm minimum on either side. The longitudinal movement shall be parallel to the conductor at frequency not less than 2 Hz for minimum one million cycles.

ii) **Vertical vibration Test:**

The spacer/spacer damper shall be installed in the middle of the test span and the frequency chosen so as to get an odd number of loops. The shaker shall be positioned at least two loops away from the test specimen to allow free movement of the conductor close to the test specimen. One conductor shall be connected to the shaker and vibrated to an amplitude such that :

$$f^{1.8} Y_{\max} > 1000 \text{ mm/sec.}$$

Where Y_{\max} being the antinode displacement (mm) and 'f' is the test frequency (Hz). The test frequency shall be greater than 24 Hz and the total number of cycles shall be more than 10 millions.

iii) **Sub-span Oscillation Test:**

The test shall be conducted for oscillation in the horizontal plane of the sample at frequency higher than 3 Hz. for minimum one million cycles. The amplitude for oscillation shall be kept equivalent to amplitude of 150 mm for a full sub-span of 80 M. Both the conductor shall be vibrated 180 deg. out of phase with above minimum amplitude.

b) **Clamp slip Test:**

The sample of spacer assembly shall be installed on test span of twin power conductor bundle string at a tension of 44.2 KN (4500 Kg.). In case of spacer for jumper, the clamp of sample shall be tightened with a specified torque. One of the clamps of the sample when subjected to a longitudinal pull of 2.5 KN parallel to the axis of conductor for a minimum duration of one minute shall not slip on the conductor the permanent displacement between the conductor and the clamp of sample measured after removal of the load, shall not exceed 1.0 mm. Similar test shall be performed on the other clamp of the same sample. Such clamp slip tests shall also be conducted after each of the vibration tests mentioned in clause 3.5(a). Each clamp shall withstand a minimum longitudinal load of 2 KN for a minimum duration of one minute after the vibration test without any adjustment of sample.

c) **Fault Current Test:**

An out -door test span of twin ACSR 'Moose' conductor shall be strung horizontally at a tension of 44.2 KN (4500 Kg.). The samples of spacer assembly shall be installed at recommended intervals simulating a normal sub span on the central sample (test specimen). A fault current of

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40 Kilo Amperes asymmetrical with 1:6 offset, shall be applied to the conductors successively for five times, each time being of a minimum duration of 5 cycles. The sample of spacer/spacer damper assembly under test, shall withstand this test without slipping on the conductor, loosening or failure of component parts.

Alternatively an equivalent compression and tension test may be conducted as follows:

The test specimen shall withstand, at least for one minute the axial and compressive load of 1500 Kg. and 750 Kg. applied between the bundle conductor strung at a sub-conductor spacing of 450 mm and at a tension

equivalent to everyday tension for 400 meters design span (22% of UTS of conductor). The centre line distance between the clamps shall be measured and recorded during the compression and tension tests. The measurement shall be recorded at (i) no load (ii) with load and (iii) after release of load. The centre line distance under load shall be within ± 100 mm of the nominal design spacing. After removal of the load, it shall be possible to return the clamps to their design position with only elight hand pressures. After the tests no other deformation or functional impairment of the spacer/spacer damper shall be visible.

d) **Ozone Test:**

The test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2x magnification.

e) **Movement Test:**

The sample assembly shall be capable of the following movements without damaging the power conductor, assuming one power conductor as fixed and the other moving. The power conductors shall be tensioned at 44.2 KN (4500 Kg.).

- | | | |
|------|---|--------------|
| i) | Longitudinal movement parallel to the power conductor | ± 50 mm |
| ii) | Vertical movement in a vertical direction at right angle to the power conductor. | ± 25 mm |
| iii) | Torsional movement/angular movement in a vertical plane parallel to the power conductor | ± 5 deg. |

f) **Corona Extinction voltage test(Dry):**

As per clause 1.2 above.

g) **Radio interference voltage test (As per IS:8263)**

As per clause 1.3 above.

3.6. **Magnetic Power Loss Test for Spacer:**

The sample involving ferrous parts shall be tested in a manner to simulate service conditions for 50 Hz pure sine-wave A.C. The test shall be carried out at various currents ranging from 400 Amperes to 800 Amperes and the magnetic power loss at various currents shall be specified in a tabulated graphical form. The difference between the power losses without and with sample at room temperature shall be limited to 1 watt for 600 Amperes current (rms). The losses shall be determined by averaging the observations obtained from a group of at least four samples tested simultaneously.

3.7 **Mechanical Strength Test for Earthwire Suspension/Tension Clamps**

a) The suspension assembly /tension assembly (excluding tension clamp) shall be subjected to a load equal to 50% of the specified minimum UTS which shall be increased at a steady rate to 67% of the minimum UTS specified. This 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 loosen the nuts initially. The assembly shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached 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.

b) Clamp slip strength Vs Torque Test for Suspension Assembly.

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of earthwire shall be fixed in the clamps. The clamp slip strength at various tightening torques shall be obtained by gradually applying the load at one end of the earthwire. The clamp slip strength Vs torque curve shall be drawn. The clamp slip strength at the recommended tightening torque shall be more than 12KN but less than 17 KN.

c) Slip strength Test of tension clamp

Tension clamps shall be compressed on a 5m length of earthwire on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load of 50% of the specified breaking load of the earthwire shall be applied and the sample shall be marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 95% of the specified breaking load and maintained for one minute. There shall be no movement of the earthwire relative to the fitting during this one minute period and no failure of the fitting also.

d) Electrical Resistance Test of Tension Clamp

The tension clamp and the jumper shall be compressed on two suitable lengths of earthwire. The electrical resistance shall be measured between points on earthwire near the clamp and near the jumper mouth keeping 25mm clearance of the fitting and should not exceed 75% of the measured resistance of equivalent length of earthwire. The test shall be conducted with direct current. The current connections shall be at a distance not less than 50 times the diameter of earthwire from the fitting and shall be made so that effective contact is ensured with all those strands of the earthwire which would be taken into account in calculating its equivalent resistance. The test shall be repeated with the polarity reversed and the average of the two results considered as the measured value.

3.8 Corona Extinction Voltage Test (Dry):

As per clause 1.2 above.

3.9 Radio Interference Voltage Test (Dry)

As per clause 1.3 above.

3.10 Chemical Analysis Test:

Chemical analysis of the materials used for manufacture of items shall be conducted to check the conformity of the same with Technical Specification and approved drawing.

4.0 TESTS ON ALL COMPONENTS (As applicable) :

4.1 Chemical Analysis of Zinc Used For Galvanising

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

4.2 Test For Forgings

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

4.3 Tests On Castings

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

5 TESTS FOR ARMOUR RODS

5.1 Tensile strength test

Each rod of a set of armour rods when tested in a tensile testing machine shall not fail at strength less than 36 Kg/mm sq.

5.2 Corona test

With the sample of armour rods wrapped on 5 metre long 31.77 mm dia pipe arranged as a horizontal Twin bundle with 450 mm sub conductor spacing, when subjected to 50 Hz phase to earth voltage simulating the maximum surface gradient as obtained on the line corresponding to 320 kV (rms) phase to ground under dry conditions, there shall be no evidence of corona on any part of the sample when all possible sources of corona are photographed in a darkened room. Corona extinction and inception voltages shall be measured.

5.3 Slip strength test

A set of armour rods shall be applied to Moose conductor and a suspension clamp shall be installed with the recommended bolt torque at the middle of the armour rods. The assembly when tested for 'Slip strength test' for suspension clamp as per clause 7.5.4.1 of IS: 2488 (Part-I), shall conform to provision of slip strength as stipulated at clause No. 11.1.1. of the IS:2486 part-I.

5.4 Bend test

The armour rod shall be wrapped on the conductor as per standard procedure. The whole assembly should then be bent in such a manner so as to form a semi circle. The assembly then should remain in this stage for a period of one minute and there should not be any rupture or permanent set when the ends of the test piece are released from the clamping position (reference clause 7.10.1 of IS: 2121(Pt-I)).

5.5 Resilience test

A set of preformed armoured rod shall be wrapped and then unwrapped on a piece of conductor 5 times successively. The preformed armour rod should not lose its resilience even after 5 applications and should be able to pass the slip strength test as mentioned (IS: 2121-Part-I).

ANNEXURE-B

PROCEDURES FOR ACCEPTANCE TESTING ON HARDWARE FITTINGS & LINE ACCESSORIES

1. MID SPAN COMPRESSION JOINT FOR CONDUCTOR AND EARTH WIRE

a) Hardness Test:

As per the value guaranteed by the bidder.

The Brinell hardness at various points on the steel sleeve of conductor core and of the earthwire compression joint and tension clamp shall be measured.

b) Failing load test:

As per clause No. 3.1(a) of Annexure-A

2. POWER CONNECTOR FOR CONDUCTOR

Axial Tensile Load Test for welded Portion

Same as per clause 3.2 of Annexure-A

3. FLEXIBLE COPPER BOND

Slip Strength Test:

Same as per clause 3.3 of Annexure-A

4. VIBRATION DAMPER FOR POWER CONDUCTOR AND EARTH WIRE

a) Verification of Resonance Frequencies:

The damper shall be mounted on a shaker table and vibrated at damper clamp displacement of ± 0.5 mm to determine the resonant frequencies of the damper. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonant frequencies thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz. shall be allowed.

b) Clamp Slip Test:

Similar to clause 3.4 (c) (ii) of Annexure-A.

c) Clamp bolt Torque Test:

The clamp shall be attached to a section of the power conductor/ earthwire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up shall be as described in clause 3.4(c) (i) of Annexure-A.

d) Strength of the Messenger Cable:

The messenger cable sample shall be fixed in a suitable tensile testing machine and a tensile load shall be gradually applied until yield point is reached. The load shall be not less than the value guaranteed by the contractor/supplier. Alternatively, each strand of messenger cable may be fixed in suitable testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the cable. The load shall be not less than the value guaranteed by the Contractor.

e) Mass Pull Off Test:

Each mass shall be pulled off in turn by fixing the mass in one jaw and the clamp in the other of a suitable tensile testing machine. The longitudinal pull shall be applied gradually until the mass begins to pull out of the messenger cable. The pull off loads shall not be less than the values guaranteed by the contractor/ supplier.

f) Dynamic Characteristics Test

The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below

Vibration Damper of conductor	1 Sample for 1000 Nos. & below
	3 Samples for lot above 1000 Nos. upto 5000 Nos.
	Additional 1 sample for every additional 1500 pieces above 5000

The acceptance criteria will be as follows:-

- i) The above dynamic characteristics curve for reactance and phase angle will be done for frequency range of 5 Hz to 40 Hz for vibration damper for 'Moose' conductor and 10 Hz to 60 Hz for vibration damper for earthwire.
- ii) If all the individual curves for dampers are within the envelopes as already mentioned for type test for reactance & phase angle, the lot passes the test.
- iii) If individual results do not fall within the envelope, averaging characteristics shall be done.
 - a) Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.
 - b) Similar averaging shall be done for phase angle.
 - c) Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.
 - d) The above curves should be within the envelope specified.

5 SPACER**a) Test Set up**

The test set up for the tests described hereunder shall be as per clause 3.4 (c) (i) of Annexure-A.

b) Movement Test:

Same as per clause 3.5 (e) of Annexure-A, which is as under.

The sample of spacer assembly shall be capable of the following movements without damaging the power conductor, assuming one power conductor as fixed and the other moving. The power conductors shall be tensioned at 44.2 KN (4500 Kg.)

- i) Longitudinal movement parallel to the power conductor ± 50 mm
- ii) Vertical movement in a vertical direction at right angle to the power conductor. ± 25 mm
- iii) Torsional movement/angular movement in a vertical plane parallel to the power conductor ± 5 deg.

c) Compressive and Tensile Tests:

The sample of spacer/spacer damper assembly shall withstand the ultimate compressive load of 14.72 KN and a tensile load of 7.3 KN applied between sub conductor bundle tensioned at 44.2 KN (4500 Kg) and held for one minute without failure. Linear distance between clamps shall be recorded during each of the compression and tension tests. Measurements shall be recorded at (i) no load (ii) with load (iii) after release of load. The centre line distance under load shall be within ± 100 mm of the nominal design spacing. After release of load, it shall be possible to retain the clamps at their original position using only slight hand pressure. There shall be no deformation or damage to the sample of spacer assembly, which would impair its function of maintaining the normal spacing.

d) Clamp Slip Test:

Similar to Clause 3.5 (b) of Annexure-A.

e) Clamp Bolt Torque Test

The sample of spacer assembly shall be attached to the power conductor tensioned at 44.2 KN (4500 Kg). A torque of 150 percent of the manufacturer's specified torque shall be applied to the clamp bolts or cap screws. There shall be no failure of the component parts.

f) Assembly torque Test

The sample of spacer/spacer damper assembly shall be installed on the power conductor (31.77mm) tensioned at 44.2 KN (4500 Kg.). The sample shall not rotate on either clamp on applying a torque of 0.04 KN either clock wise or anti-clockwise direction.

g) Hardness test for Elastomer

The shore hardness at different points on the elastomer surface of cushion grip clamp shall be measured by shore hardness meter. They shall be between 65 to 80.

h) UTS of Retaining Rods

The ultimate tensile strength of the retaining rods shall be measured. The value shall not be less than 35 kg/sq. mm.

6. REPAIR SLEEVES FOR CONDUCTOR AND EARTH WIRE

Dimensional verification:

All dimensions shall be checked against approved drawing (s).

7. HARDWARE FITTINGS:

a) Galvanising test:

The test shall be carried out as per clause 5.9 of IS: 2496 (Part-I) except that both uniformity of zinc coating and standard preece test shall be carried out and results obtained shall satisfy the requirements of specification.

b) Mechanical strength test for welded joint:

The welded portion of the component shall be subjected to a load of 2000 Kgs. For one minute. Thereafter, it shall be subjected to die-penetration/ultrasonic test. There shall not be any crack at the welded portion.

c) Shore hardness test of elastomer cushion for AGS assembly:

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The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall lie between 65 to 80.

d) **Clamp slip strength V/s torque test for suspension clamp:**

As per clause 2.5 of Annexure-A.

8. **ARMOUR ROD**

a) **Hardness test:** (As per the value guaranteed by the bidder.)

CHAPTER-8**OPTICAL POWER GROUND WIRE (OPGW) DETAILED TECHNICAL SPECIFICATION**

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CHAPTER-8

SPECIFICATIONS FOR OPGW CABLING AND ASSOCIATED HARDWARE & FITTINGS

8.1 Scope:

The OPGW cable comprises a ground wire (containing aluminium and steel) with optical fibres in the core or first layer. The OPGW cable replaces the normal ground wires and therefore has to fulfill all the electrical and environmental requirements which affect the ground wire. The fittings, accessories to be supplied shall be suitable for the OPGW type. The OPGW Cables will be used on the transmission lines of Voltage upto 400 kV.

The scope covers survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, splicing, termination, testing, training, and demonstration for acceptance, commissioning and documentation for OPGW fibre optic cable including all associated hardware, accessories & fittings, Splicing of fibres and Training. In case of length of OPGW to be laid measures more than 250 km. then provision for repeater station is to be made at suitable tower location in consultation with employer.

This section describes the functional & technical specifications of OPGW cabling and associated hardware & fittings.

8.2 Fibre Optic Cabling

This section defines the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

8.3 Required Optical Fibre Characteristics

This section describes the characteristics of optical fibre to be provided under this specification.

8.4 Physical Characteristics

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 8-1.

8.5 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 8-1 shall be "guaranteed" fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: $0.21 \text{ dB/km} \times \text{total km} + 0.05 \text{ dB/splice} \times \text{no. of splices} + 0.5 \text{ dB/connector} \times \text{no. of connectors}$

Maximum attenuation @ 1310nm: $0.35 \text{ dB/km} \times \text{total km} + 0.05 \text{ dB/splice} \times \text{no. of splices} + 0.5 \text{ dB/connector} \times \text{no. of connectors}$.

Table 8-1
DWSM Optical Fibre Characteristics

Number of optical fibres in OPGW	24
Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 0.6\mu\text{m}$)
Cladding Diameter:	125.0 $\mu\text{m} \pm 1 \mu\text{m}$
Mode field concentricity error	$\leq 0.6\mu\text{m}$
Cladding non-circularity	$\leq 1\%$
Cable Cut-off Wavelength λ_{cc}	$\leq 1260 \text{ nm}$
1550 nm loss performance	As per G.652 D
Proof Test Level	$\geq 0.69 \text{ Gpa}$
Attenuation Coefficient:	@ 1310 nm $\leq 0.35 \text{ dB/km}$ @ 1550 nm $\leq 0.21 \text{ dB/km}$
Chromatic Dispersion; Maximum: Zero Dispersion Wavelength: Zero Dispersion Slope:	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm 0.092 ps/(nm ² xkm) maximum
Polarization mode dispersion coefficient	$\leq 0.2 \text{ ps/km}^{1/2}$
Temperature Dependence:	Induced attenuation $\leq 0.05 \text{ dB}$ (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75 \pm 2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB}$ @ 1550 nm (30 \pm 1 mm radius Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB}$ @ 1550 nm (32 \pm 0.5 mm dia Mandrel), 1 turn; Attenuation Rise $\leq 0.50 \text{ dB}$

8.6 Fibre Optic Cable Construction

Overhead Fibre Optic Cables shall be OPGW (Optical Ground Wire). The OPGW cable is proposed to be installed on the 765 kV transmission lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service.

8.7 Optical Fibre Cable Link Lengths

The Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

8.8 Optical Fibre Identification

Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be

suitably bundled, tagged and identified at the factory by the vendor.

8.9 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

8.10 Optical Fibre Strain & Sag-tension chart

The fibre optic cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of this specification, the following definitions shall apply:

- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is *no fibre strain*.
- The *no fibre strain* condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry techniques.
- The Cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable max strain is defined as the maximum strain experienced by the Cable under the worst case loading condition.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- The Ultimate /Rated Tensile Strength (UTS/ RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions mentioned below:

1. 53° C, no wind and no ice
2. 32° C, no wind and no ice
3. 0°C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 0° C, 2/3rd / 36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to 600 m or higher span length in the range of 50 m spans. Max. vertical sag, max. tension and max sag at 0° C & no wind shall be considered for in line with the design parameter of transmission line. The typical details are indicated in the Appendices. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines. The Contractor shall submit the stringing chart for review of

Employer.

8.11 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

8.12 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC-794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, nonhygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

8.13 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

8.14 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

- (a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.
- (b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor.

8.15 OPGW cable installation requirements

The OPGW cable shall be installed on 400 kV transmission line.

8.16 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 1994. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of buffered optical fibre units embedded in a water tight aluminium/aluminium alloy/stainless steel protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

8.17 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials such as stainless steel tube with aluminium or aluminium – clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminium or stainless steel tube with aluminium protective coating. In case of aluminium protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

8.18 Basic Construction

The cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 8.2 OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

8.19 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

8.20 Electrical and Mechanical Requirements

Table 8-2 provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable IS 802:1995 and IS 875: 1987 shall be applied. However the OPGW installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 8.2
OPGW Electrical and Mechanical Requirements

(1)	Everyday Tension	$\leq 20\%$ of UTS of OPGW
(2)	D.C. Resistance at 20°C:	< 1.0 ohm/Km
(3)	Short Circuit Current:	≥ 6.32 kA for 1.0 second

8.21 Operating conditions

Since OPGW shall be located at the top of the EHV transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

8.22 Installation

The stringing procedure shall be submitted by the Contractor prior to stringing for Employer's approval. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

8.23 Installation Hardware

The scope of supply of the optical cable includes the assessment, supply and installation of all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The Contractor shall determine the exact requirements of all accessories required to install and secure the OPGW.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

- (a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 kN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured in accordance with type test procedures specified.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

- (b) Dead End Clamp Assemblies: All dead end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

- (c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth

suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

- (d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.
- (e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in Appendix, Vol II. Vibration damper clamps shall be made of aluminium or aluminium alloy, shall support the dampers during installation and shall maintain the dampers in position without damage to the OPGW and without causing fatigue. Armour or patch rods made of aluminium or aluminium alloy shall be provided as required to reduce clamping stress on the OPGW. The vibration damper body shall be hot-dip galvanised mild steel/cast iron or shall be permanent mould cast zinc alloy.

8.24 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply to ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 6 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

8.25 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

- (a) All fibre splices shall be accomplished through fusion splicing.
- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than six (6) fibres shall be installed in each splice tray.
- (d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.
- (e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

8.26 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

- (a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.
- (b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.
- (c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.
- (d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.
- (e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

8.27 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification .The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

8.28 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

- (a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti- corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.
- (c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

8.29 Inspection and Testing Requirement

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall furnish all manpower and materials for tests, including testing facilities, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector i.e. Employer's representative.

Acceptance or waiver of tests will not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer representative unless the Employer authorises testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

The Employer also reserves the right to require any retesting of previously approved tests at the Purchaser's expense. However if the retest(s) reveal non compliance to the specification, the Contractor shall bear the expense for the retesting and remedial action.

8.30 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

- (a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.
- (b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings, and labelling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.
- (c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
- (d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior

to shipping this equipment to the Contractor's facility or directly to the Employer.

- (e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

8.31 Test Plans and Procedures

Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

The Contractor shall submit a Test Schedule for the Employer's approval within three (3) months after the award of contract for all tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

8.32 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for the Employer approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 8-3.

**Table 8-3
Factory & field Test Plan Requirements**

Item:	Description:
1.	Test schedule
2.	Record-keeping assignments, procedures and forms
3.	Procedures for monitoring, correcting and retesting variances
4.	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

8.33 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 8-4.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ zig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

**Table 8-4
Test Procedure Requirements**

Item:	Description:
1.	Test Title and Revision Level, if applicable

2.	Function(s) / parameter(s) to be tested
3.	Purpose of each test segment
4.	List of required test equipment
5.	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.
6.	Test set up including test configuration block diagrams and/or illustrations.
7.	Test procedures to be followed.
8.	Required inputs and expected outputs for each test segment
9.	Acceptance criteria for each test segment.
10.	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
11.	Format of test reports.

8.34 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 8-5.

**Table 8-5
Test Record Requirements**

Item:	Description:
1.	Test Title and Revision Level, if applicable; contract references
2.	Date and time for test start and test completed
3.	Test title and reference to the appropriate section of the test procedures
4.	Description of any special test conditions or special actions taken (Includes test-case data).
5.	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6.	Test procedure modifications made during testing.
7.	Variance Report(s) tracking information and copies (if variance(s) was detected).
8.	Contractor's test engineer(s) identification, signature and remarks
9.	the Employer's test witness identification, signature and remarks
10.	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test.

These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within 30 calendar days of completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

8.35 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

8.36 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract/ Special Condition of Contract and their correlation with the tests requirements described within this section is as follows:

- a. Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)
- b. Operational Acceptance - Completion of "Guarantee Test" as defined in GCC/SCC, successful completion of SAT for all FO links and submission of all drawings/documents as per technical specifications requirement.

8.37 Testing Requirements

Following are the requirements of testing under Fibre Optic Cabling Package:

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

8.37.1 Type Testing

Type tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this specification. The test reports for these tests shall be furnished by the contractors as per the requirement of clause no. 1.1 "Technical Evaluation " of section 3, EQC.(Vol I)

8.37.3 List of Type Tests

8.37.3.1 Type Tests for Optical Fibres

The type tests listed below in table 8-6 are conducted on DWDM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Table 8-6

Type Tests For Optical Fibres

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Specification	IEC 60793-1-40 Or EIA/TIA 455-78A
2	Attenuation Variation with Wavelength		IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak		IEC 60793-1-40 Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 Or EIA/TIA455-176
9	Point Discontinuities of attenuation		IEC 60793-1-40 Or EIA/TIA455-59
10	Core -Clad concentricity error		IEC 60793-1-20 Or EIA/TIA455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-31 Or EIA/TIA 455-31B

8.37.3.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in table 8-7 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not

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increase by more than 0.05 dB/Km.

Table 8 - 7
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
1	Water Ingress Test	IEEE 1138 Section 4.1.1.1	IEEE 1138, Section 5.1.1.1 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138 Section 4.1.1.2	IEEE 1138 Section 5.1.1.2 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE 1138 Section 4.1.1.3	IEEE 1138 Section 5.1.1.3	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		Initial temperature during the test shall be greater than or equal to ambient field temperature.
4	Aeolian Vibration Test	IEEE 1138 Section 4.1.1.4 Or IEC60794-4-10 / IEC 60794-1-2, Method E19	IEEE 1138 Section 5.1.1.4	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.

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5	Galloping test	IEEE 1138 Section 4.1.1.5	IEEE 1138 Section 5.1.1.5	Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138 Section 4.1.1.6 Or IEC 60794-1-2 (2003) Method E18B	IEEE 1138 Section 5.1.1.6	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138 Section 4.1.1.7	IEEE 1138 Section 5.1.1.7 (IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400- metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.

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9	Impact Test	IEEE 1138 Section 4.1.1.7	IEEE 1138, Section 5.1.1.7 (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius + 10% A
10	Creep Test	IEEE 1138 Section 4.1.1.8	IEEE 1138 Section 5.1.1.8	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be calculated.
11	Fibre Strain Test		IEEE 1138 Section 4.1.1.9	IEEE 1138 Section 5.1.1.9
12	Strain Margin Test		IEEE 1138 Section 4.1.1.10	IEEE 1138 Section 5.1.1.10
13	Stress strain Test		IEEE 1138 Section 4.1.1.11	IEEE 1138 Section 5.1.1.11
14	Cable Cut-off wavelength Test		IEEE 1138 Section 4.1.1.12	IEEE 1138 Section 5.1.1.12
15	Temperature Cycling Test		IEEE 1138 Section 4.1.1.13	IEEE 1138 Section 5.1.1.13 Or IEC 60794-1-2, Method F1
16	Corrosion (Salt Spray) Test		EIA/TIA 455-16A	
17	Tensile Performance Test		IEC 60794-1-2 E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.
18	Fault Current/ Lightning Test		IEC 60794-4-10 / IEC 60794-1-2 (2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.
19	DC Resistance Test (IEC 60228)		On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.	

8.37.3.3 Type Test on OPGW Cable Fittings

The type tests conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16° . This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached 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 shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached 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 shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

* Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.
- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on a 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95 % of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or

OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

8.37.3.4 Type Test on Vibration Damper

(i) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band as determined through vibration analysis of undamped OPGW. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

- (a) Force Vs frequency
- (b) Phase angle Vs frequency
- (c) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

The above dynamic characteristics test shall be conducted on five dampers. The variations between the samples tested shall conform to the sample test limits.

(ii) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

- (d) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as max Permissible Every Day Tension (20% of UTS), for a span ranging from

100 m to 1100 m.

- (e) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.
- (f) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (g) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
- (h) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

8.37.3.4.1 Vibration Damper Clamp Slip and Fatigue Tests

(i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 15 kN and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Clamp Slip Test

The vibration damper shall be installed on the test span. The damper clamp, after tightening with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of fibre optic cable for a minimum duration of one minute shall not slip, i.e., the permanent displacement between fibre optic cable and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased until the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

(iii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be

identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than $\pm 25/f$ mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein above shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

- (i) There shall not be any frequency shift by more than ± 2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.
- (j) The force response curve shall generally lie within guaranteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Supplier.
- (k) The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Supplier. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

8.37.3.5 Type Tests for Splice Enclosures (Joint Box)

Following Type tests is conducted on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to $+65^{\circ}\text{C}$ with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than $\pm 0.05\text{dB}$. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than $\pm 0.05\text{dB}$, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than $\pm 0.05\text{dB}$.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

- a) 3 torsion cycles of $\pm 180^\circ$ shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 flexure cycles of the cable, of $\pm 180^\circ$ with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than $\pm 0.05\text{dB}$. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 10 metres of cable fixed to the box, it shall be dropped five times from a height of 11 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test shall be carried out in accordance with procedure described in IEC 60068-2-32.

8.38 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected Fibre Optic Cable & associated accessories to be supplied. Factory acceptance testing shall be carried out on OPGW cable, hardware fittings & accessories, splice enclosures , etc.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employers approval to ship shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer's representatives is intimated to the Contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the Fibre Optic Cable & associated accessories in relation to this specifications and approved drawings and documents. A list of factory acceptance tests for fibre optic cables, hardware fittings & accessories are given in the Specification. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program.

The factory acceptance tests for the splice enclosures, and other items shall be proposed by the Contractor in accordance with technical specifications, Standards and Contractor's (including Sub-Contractor's /supplier's) standard FAT testing program. For Test equipment, FAT tests shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

8.39 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 1) for FO cable drums, splice enclosures and other similar items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW/ hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

8.40 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

8.41 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table 8-8 below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138, 1994. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

**Table 8-8
Factory Acceptance Tests for Optical Fibres: Optical Tests**

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	TS Vol II ,Table 2-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS Vol II, Section 2.1.1.2	EIA/TIA 455-59
3	Attenuation at Water Peak	TS Vol II ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B

The test report for the above tests for the fibres carried out by the Fibre Manufacturer and used in the OPGW shall be shown to the inspector during OPGW FAT and shall be submitted along with the OPGW FAT report.

8.42 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table 8-9 follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 8-9
Factory Acceptance Tests On OPGW

Applicable standard: IEEE 1138 / IEC 60794

S. No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

8.43 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 5-10. The sampling plan shall be as per relevant standard:

Table 8-10
Factory Acceptance Tests On OPGW Fittings

S. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
Tension Assembly	
5	Clamp Slip Strength test
6	Visual Material verification and dimensional checks as per approved DRS/Drawings
7	Mechanical strength of each component
Vibration Damper	
8	Galvanising test on damper, masses and messenger wires
9	Damper response (resonant frequencies)
10	Clamp Slip test
11	Strength of messenger wires
12	Mass pull off test
13	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
14	Clamp fit test
15	Clamp Strength test
16	Visual Material verification and dimensional checks as per approved DRS/Drawings

8.44 Factory Acceptance Test on Splice Enclosure (Joint Box)

The factory acceptance tests for Splice Enclosures as specified below in Table 8-11:

Table 8-11
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S.No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure and dimensional checks against the approved drawings.

8.45 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment including test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. A minimum Site Acceptance Testing requirement for FO cables is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO cabling installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

8.45.1 Minimum Site Acceptance Testing Requirement for OF Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

8.45.2 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and Tension of Aerial cable shall be as per approved sag tension calculation and during installation sag & tension shall be documented.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Tables 8-12 (a) through 8-12 (c).

**Table 8.12(a)
Fibre Optic Cable Pre-Installation Testing**

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3.	Fibre Optic Cable length measurement using OTDR

**Table 8-12(b):
Fibre Optic Cable Splicing Testing**

Item:	Description:
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1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

Table 8-12(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

8.46 Training

The Contractor shall provide a comprehensive training program that prepares the Employer personnel for on-site installation support, operation, and maintenance.

Training may be conducted by the Contractor, the Contractor's subcontractors, and/or manufacturers. The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English. All necessary training material shall be provided by the Contractor.

Hands-on training shall be with items identical to that being supplied to the Employer.

The schedule, location and detailed training contents shall be submitted by the Contractor to the Employer for approval.

8.46.1 Overview and Installation Training

The training shall be oriented to a user's point of view. The Employer users will include managers, design & planning personnel, communication support staff and maintenance personnel.

The overview training shall be customized for the specific functions, features, and items purchased by the Employer; it shall not be a general presentation of the Contractor's standard equipment repertoire. Personnel assigned by the Contractor to implement the Employer's system shall conduct this overview training. The Employer shall review and approve the contents of the overview training at least four (4) weeks prior to the course.

The training courses shall also provide the Employer personnel with an in-depth working knowledge of the equipment, and operation of the test equipment / diagnostic tools. The courses shall provide personnel with a theoretical background and extensive hands-on experience.

8.46.2 Supervision, Maintenance and Installation Crew Training at Site

The Installation, Supervision & Maintenance training course shall enable the trainees to effectively supervise the fibre optic cable installation work from an Employer perspective, particularly with respect to installation quality checks and safety procedures. The training shall cover FO cable handling techniques, stringing and installation, jointing & splicing, OTDR use and OTDR trace analysis, operation, preventive maintenance, troubleshooting procedures, corrective maintenance, and expansion procedures.

It shall also cover an appreciation of restorative procedures required after any likely cable failure such

as cable breaks due to storms or falling trees, installation hardware failures or misalignments.

Installation crew training shall be predominantly hands-on training courses provided for a group of persons. The intent of this training is to enable Employer to undertake maintenance & restoration work in case of cable breaks or other such failures.

The Contractor shall submit for approval a detailed proposal for this training as per the agreed documentation schedule. The proposal shall include information such as proposed number of trainees, trainee profile, course duration, training facilities and methodology to be used etc. The training charges for this training course shall be separately identified in the Bid Price Schedules.

8.46.3 Fibre Optic cable Installation and Maintenance Training

There shall be installation & maintenance training for Fibre Optic cable & associated items. The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive & restorative maintenance of the Fibre Optic cable & associated items purchased by the Employer. The training courses shall cover Fibre Optic cable & associated items installation, testing & commissioning, preventive maintenance, diagnostic tools and troubleshooting procedures, corrective maintenance for Fibre Optic cable. The courses shall provide theoretical background and extensive hands on experience.

8.47 Manuals and Equipment

The Contractor, subcontractor, or OEM shall prepare training manuals and submit them to the Employer for review at least one month prior to the start of training. The training manuals shall be prepared specifically for use as training aids; reference manuals, maintenance manuals, and user's manuals may be used as supplementary training material. Principal documents used for training shall be tailored to reflect all the Employer requirements specified.

Each course participant shall receive individual copies of training manuals and other pertinent material at least two weeks prior to the start of each course. The Employer shall retain a master and two additional copies of all training manuals and materials as reference documentation.

Upon completion of each course, instructor's manuals, training manuals, and training aids shall become the property of the Employer. As part of the delivered system documentation and the final documentation, the Contractor shall supply the Employer with all changes and revisions to the training manuals and other training documentation. The Employer reserves the right to copy all training manuals and aids and training material/handouts for use in the Employer conducted training courses.

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LIMITED

SUB SECTION - III

STANDARD FIELD QUALITY PLAN

FOR

TRANSMISSION LINE PACKAGE

SPECIFICATION FOR CONCRETING OF FOUNDATIONS

1.1 SCOPE

This specification covers the requirement in respect of material used in forming, concrete, mixing, placing, finishing, curing and testing of plain reinforcement cement concrete for transmission lines tower foundations.

1.2 STANDARDS

1.2.1 Except where otherwise specified or implies, the concrete shall conform to the provisions of IS 456-2000(as amended up-to-date).

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

IS 269	Specification for the ordinary Rapid hardening and low heat Portland cement.
IS 383	Specification for Coarse and Fine Aggregate from Natural Sources for Concrete.
IS 5613(Part 3/ Section 2)	Code of practice for design installation and maintenance of overhead power lines.
IS 4091	Code of practice for design and construction of foundation for transmission in tower and poles.

1.2.3 The water used for mixing and curing the concrete shall be potable, clean and free from injurious quantities of slit, oils, acids, alkalies, salts and organic material and other deleterious substances.

1.2.4 Admixtures shall be used, if necessary, only with the written permission of the Engineer-in-charge. Addition of admixtures shall not reduce the specified strength of concrete in any case. The admixtures shall conform to IS 9103 (Latest edition)

1.3 GRADES OF CONCRETE

1.3.1 Concrete of grade M- 20 shall be used for the main foundations comprising base slab pad, pyramid and chimney and that of grade M-10 for sub-base. Where pile foundations are to be used these shall be constructed with concrete of M- 25 Grade. The design and construction of pile foundations shall be in accordance with the Sub Section I Chapter 1. The properties of concrete and mix design shall be as given in IS:456 (as amended up-to-date). The proportion of cement, sand and aggregates in the above mixes are subject to change to obtain a strength of M-25, M-20 and M- 10 concrete at the discretion of the Engineer-in-charge.

1.4 SIZE OF AGGREGATE

1.4.1 The sizes of aggregate used in the concrete, shall be 20 mm nominal size.

1.5 CONCRETE MIX REVIEW

1.5.1. The source and quality of concrete materials and concrete proportions proposed for the work shall be submitted to the Engineer-in-charge for review before the concrete work is start. Complete certified reports prepared by an independent testing laboratory and covering the materials and proportions shall be submitted to the Engineer-in-charge. Review of these reports will be for general acceptability only and continued compliance within all contract provisions only will be required. The Engineer-in-charge shall have the option to witness the preparation of the trial mixes, testing etc.

- 1.5.2. Reports on admixtures shall include the classification, brand, manufacturer and active chemical ingredient. All admixtures, conforming to relevant IS codes, shall be the products of one manufacturer approved by the Engineer-in-charge.
- 1.5.3. Reports on the fine aggregates shall include the sources, type, gradation deleterious substances, soundness and the results of all tests required to verify compliance with IS:383 (latest edition).
- 1.5.4. Reports on the coarse aggregates shall include the source, type gradation, deleterious substances, soundness, abrasion loss and the results of all tests required to comply with IS:383(latest edition).
- 1.5.5. Using concrete materials acceptable to the Engineer-in- charge a tentative concrete mix shall be designed and tested for each size and gradation of aggregates and for each consistency intended for use on the work. Designed quantities and test results of each mix shall be submitted for review. Acceptable mixes shall be subjected to field adjustments as necessary to meet the requirements of these specifications.
- 1.5.6. The report for each tentative concrete mix submitted for review shall include the following information:
 - i) Slump on which the design is based.
 - ii) Total litres of water per cubic metre.
 - iii) Water-cement ratio.
 - iv) Ratio of fine to total aggregates.
 - v) Weight(surface dry) of each aggregates per cubic metre.
 - vi) Quantity of each admixtures.
 - vii) Air content, if any.
 - viii) Compressive strength based on 7 days and 28 days compression tests.
 - ix) Time of initial set.
 - x) Time of final test.
 - xi) Weight of cement used in the
- 1.5.7 Concrete tests specimens shall be maiden cured and tested in conformance with IS:516 (latest edition). These tests shall be conducted at approved laboratory. The moulds and materials for cubes and cylinders shall be supplied by the Contractor who shall also arrange to transport the cubes/cylinders to laboratory at his cost. Actual cost of the testing shall also be borne by the Contractor.

1.6 CONCRETE MIX REQUIREMENTS

- 1.6.1 Nominal mix concrete as defined in IS: 456 shall be used for all foundations.
- 1.6.2 Concrete mix shall conform to IS: 456(latest edition).
- 1.6.3 Concrete slump shall be kept as low as possible consistent with proper handling and through compaction.
- 1.6.4 The concrete shall be of such consistency as to give a slump of 75 to 100 mm with a maximum water cement ratio on 0.50. Use of admixtures for increasing the workability and/or retarding the initial setting time of concrete may be used subject to approval by the Engineer-in- charge.
- 1.6.5 The admixtures content, batching methods and time of introduction to the mix shall be in accordance with the manufacturers for compliance with these specifications.
- 1.6.6 The minimum compressive strength of 15 centimeter concrete cubes, as determined by IS: 516(latest edition) shall be as follows:

Grade of Concrete	M-15	M-20
i) Preliminary Tests at 28 Days	20.0N/mm ²	26.0N/mm ²

	(204 Kg/CM ²)	(265 Kg/CM ²)
ii) Work Test at 7 days	10.0N/mm ²	13.5N/mm ²
	(102 Kg/CM ²)	(138 Kg/CM ²)
iii) Work Tests at 28 days	15.0N/mm ²	20.0N/mm ²
	(153 Kg/CM ²)	(204 Kg/CM ²)

- 1.6.7 Nominal mix concrete shall be used. The minimum cement content per cubic meter for nominal mix concrete shall be as under not withstanding the strength requirement (28 days specified at clause 1.6.9 above).

Grade of concrete/ Nominal mix	Minimum cement content per cum.
a) M- 10 (1:3:6)	225 kgs.
b) M- 15 (1:2: 4)	325 kgs.
c) M- 20 (1:1.5:3)	410 kgs.
d) M- 25 (1:1:2)	560 kgs.

Note: **WORK TESTS**

A test conducted in the field or in a laboratory on the specimen made on the works, out of the concrete being used on the works.

- 1.6.8 Nominal mix concrete shall be used on all concrete works, except where specified otherwise. Work shall not commence until the Engineer-in-charge has approved the nominal concrete mix. The Contractor shall allow sufficient time for all the obligations and test etc. to be carried out prior to approval.

1.7 **CONCRETE MIXING**

- 1.7.1 Concrete mixing shall conform to IS: 456 (latest edition), Concrete shall normally be mixed in a mechanical mixer. Mixing of metallic water tight platform shall be allowed only in very difficult approach area.
- 1.7.2 The proportion of fine and coarse aggregates, cement and water shall be as determined by the nominal mix concrete. The quantities of fine and coarse aggregates shall be determined by weight. The Engineer-in-charge may allow the quantity of aggregates to be determined by equivalent volume basis after the relationship between the weight and volume is well established by trial and the same will be verified frequently. The quantity of cement shall always be determined by weight. The water shall be measured accurately after giving proper allowance for surface water present in the aggregates for which regular check shall be made for bulking in the case of volume batching in accordance with IS:2386(Part-III).
- 1.7.3 All concrete shall be mixed until there is a uniform distribution of materials and shall be discharged completely before the mixer is recharged. Water shall not be added to the mix until all the cement and aggregates constituting the batch are already in the drum and dry mixed for at least one minute. Mixing shall be done in a mechanical mixer and the type and size shall be subjected to the approval by the Engineer-in-charge. Mixer shall be rotated at a speed recommended by the manufacturer and the water shall not be added to the mix until all the cement and aggregates constitution the batch are already in the drum and dry mixed for at least one minute and thereafter mixing shall be continued for at least 2 minutes and at least forty(40) revolutions after all materials are in the drum. For batches large than 0.75m³, mixing time shall be increased by 15 seconds for each additional 0.75 m³ or fraction thereof. All concrete shall be discharged within 3 minutes after the introduction of mixing water to the cement and aggregates, unless a different time is specified by the Engineer-in- charge.
- 1.7.4 Before beginning a run of concrete all partially set or hardened concrete and foreign material shall be removed from the inner surface of mixing and conveying equipment. The first batch of concrete, through a cleaned mixer, for use in the works, shall contain 10% additional cement at no extra cost to the owner to allow for loss in the drum. All cleaned at frequent intervals during the placing of concrete. Concrete shall be rapidly handled from the mixer to the place of final deposit and shall not be delivered by spout or troughs nor dumped into carriers with a free fall from the mixer of more than 1 m. Every possible precaution shall be taken to prevent separation or loss of the ingredients while transporting the concrete.

1.7.5 In the stretches involving heavy foundations work if practicable, centralised mixing shall be arranged so that mixing action in mixers can be observed by the Purchaser or his representative. Mixers shall not be loaded in excess of their rated capacity.

1.7.6 When a truck mixer of agitator is used for transporting concrete, the concrete shall be delivered to the site and the discharge completed within one and half hours after the introduction of constituents of concrete into mixer. In no case the maximum net water-cement ratio shall be exceeded.

1.8 CONCRETE PLACEMENT

1.8.1 The handling, depositing, the compacting of concrete shall conform to these specifications, subject to adjustments by the Engineer-in-charge for weather or placements conditions. During hot or cold weather the concreting shall be done as per the procedure set out in IS:7861 Part I & II (latest edition).

1.8.2 Concrete shall not be placed until the form work, reinforcements and preparation of surfaces involved in casting are approved by the Purchaser and shall be placed only in the presence of Purchaser or his representative. Preferably concrete shall not be placed under water and all excavations prepared for concrete shall be maintained free of water until the concreting is completed 24 hours thereafter. All surfaces of foundations upon or against which concrete is placed shall be free from mud and loose earth.

1.8.3 Contractor shall keep on accurate record of the date on which the concrete is cast for each part of work and date on which the forms are removed.

1.8.4 Concrete shall be conveyed to the point of final deposit by methods which will prevent the separation or loss of the ingredients. Concrete shall be deposited in its final position without moving it laterally in the forms for a distance in excess of 1.5 metre.

1.8.5 Concrete shall be deposited in approximately horizontal layers to proper depth for effecting compaction. However, the depth of a layer shall not exceed 500 mm. Each layer of concrete shall be plastic when covered with the following layer and the forms shall be filled at a rate of vertical rise of not less than 150 mm per hour. Construction joints shall be provided as necessary and as accepted by the Engineer-in-charge to comply with these requirements.

1.8.6 Plastic concrete is defined as concrete which can be revibrated at least to the extent that an immersion type vibrator spuds will penetrate the concrete at least 25 mm by vibration action and its weight. Concrete which is no longer plastic but which must be covered by an additional lift shall be immediately chipped back to well consolidated concrete and flushed with mortar puddle as follows.

The surface of hardened concrete upon which fresh concrete is to be placed shall be wrought and clean and damp. Surface mortar shall be removed to expose the aggregate. The hardened surface shall be cleaned of all foreign substances (including curing compound), washed with clean water, and kept saturated during the 24 hours period proceeding placement of fresh concrete. Coarse aggregates shall be omitted from the batches of concrete deposited on hardened concrete. This mortar puddle shall cover the hardened concrete to a depth of not less than 15mm at every point.

1.8.7 To secure maximum density and eliminate formation of air pockets, the concrete shall be thoroughly vibrated and worked around all reinforcement, embedded facilities and into corners of forms during and immediately after placing. Unless other methods are authorised by the Engineer-in-charge, mechanical vibrator, conforming to IS 2505, IS 2506, IS 2514 and IS 4656 (all latest edition) shall be used for this purpose, the type and operation of which is subjected to the approval of the Engineer-in-charge.

1.8.8 The placing of concrete shall be in a continuous operation with no interruption in each location. Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by the methods, which, which will prevent segregation.

1.8.9 Concrete shall normally be placed in continuous horizontal layers. Construction joints in foundations shall not be permitted. Concrete shall be compacted to the maximum practicable

density during the placement and thoroughly worked around the reinforcement if any and around the embedded stubs and into the corners of the form work, with vibrators or any other means approved by the Purchaser.

- 1.8.10 Repair of imperfection in concrete shall be complete within 24 hours after the removal of forms. Repair of concrete shall be performed only in the presence of the Purchaser or his representative. All exposed corners shall be slightly rounded or chamfered. Concrete in the top of footings shall be sloped to provide drainage away from stub angles.

1.9 TEMPERATURE OF CONCRETE

- 1.9.1 In hot weather the temperature of the concrete when it is placed in the forms shall not be more than 38 deg. Celsius. In extreme hot weather some suitable means out of those mentioned below shall be employed to lower the temperature of concrete:

- a) Using cold mixing water.
- b) Cooling coarse aggregate with cold water by sprinkling or inundation.
- c) Insulating mixer drums or cooling them with sprayers or with wet burlop coverings.
- d) Shading materials and facilities not otherwise protected from heat.
- e) Working only at night. Use of ice for mixing water should be carefully controlled to ensure complete melting before mixing is completed.

- 1.9.2 In cold weather the temperature of concrete when it is placed at or below freezing temperatures shall be maintained at least 4.5 deg. Celsius. No frozen material or material containing ice shall be used. Depending upon the severity of the weather, it is necessary to heat the mixing water or aggregate. Heating of mixing water shall be preferred. Very hot water shall not be allowed to touch the cement to avoid quick or flash setting hot water and coldest portion of aggregate shall be brought together in the mixer first.

- 1.9.3 If subject to the approval of the purchaser, heating of aggregate is used, the aggregate and excessive drying. The average temp. of aggregate shall not exceed 65 deg. Celsius and the max. temp. shall not exceed 100 deg. Celsius.

1.10 STRIPPING TIME

Under fair weather conditions with average daily temp. not less than 20 deg. Celsius and when ordinary cement is used, form may be struck after 24 hours of placing the concrete. In very cold temperatures, the forms shall be struck after 48 hours of the placing of concrete.

1.11 PROTECTION OF CONCRETE

- 1.11.1 In very cold weather the concrete shall be protected from freezing for at least 48 hours of placement when the mean daily temp. is 4.5 deg. Celsius for more than 1 day, the concrete shall be maintained at a temp. not less than 10 deg. Celsius for at least 72 hours if it is placed. Concrete cured by water curing shall be protected at 10 deg. Celsius.

- 1.11.2 In hot weather, the curing shall be commenced even before stripping the form work by loosening the forms and allowing curing water to run down between the concrete forms.

1.12 CURING

- 1.12.1 The concrete shall be cured for at least 10 days. The uncovered concrete footing above the ground level shall be cured by wrapping ground hessian sacking or similar absorbent material and keeping it constantly wet. For curing the foundations below ground level, after backfilling, 150mm high earthen embankment along the sides of the excavation pits shall be made and sufficient water shall be poured in the backfilled pits so that standing water may remain above the backfilled earth.

- 1.12.2 In high temp. and low humidity areas, more frequent sprinkling shall be done.

- 1.12.3 In cold weather at or below freezing temperature, concrete shall be insulated with layer of straw or similar material covered with waterproof sheet material to help retention of the original

heat of concrete plus heat of hydration. Curing shall be carried out for longer periods, to the satisfaction of Purchaser, to ensure that the concrete attains the requisite strength and quality.

1.13 SAMPLING AND TESTING

- 1.13.1 Samples of concrete shall be taken at the direction of the Engineer-in-charge in the field in accordance with IS 1199 (latest edition) "Methods of Sampling & Analysis of Concrete". The testing shall be carried out as per IS 456 (latest edition) and other relevant IS codes.
 - 1.13.2 The samples shall be tested for strength and consistency at any approved laboratory in accordance with IS 616. The moulds and material for cubes and cylinders shall be contractor who shall also arrange to transport the cubes/cylinders to the laboratory at his cost .Actual cost of the testing shall also be borne by the contractor.
 - 1.13.3 Number of samples to be taken for testing & verifying concrete strength shall be in accordance with IS 456(latest edition) and as per the directions of Engineer-in- charge.
 - 1.13.4 Samples shall be cured under laboratory conditions except when in the opinion of the Engineer-in- charge extreme weather conditions may prevail at which time the Engineer-in-charge may require additional cubes cured under job conditions.
 - 1.13.5 The contractor shall promptly furnish to the Engineer-in-charge certified reports of all tests made by the laboratory.
 - 1.13.6 If the strength of the cubes for any portions of the concrete work falls below the specified compressive strength. the criteria for acceptance of the portion of the work shall be as stipulated in IS 456.The Engineer-in-charge shall also reserve the right to reject whole or any part of the work. In case of acceptance of such work, the standard deviations shall be worked out, and examined by the Engineer-in-charge and if he is satisfied only then such works can be accepted at the reduced rates. Furthermore, the Engineer-in-charge shall have the right to order a change in the mix or the water cement ratio for the remaining portion of the foundations at no extra cost of the purchaser.
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GENERAL GUIDELINES FOR IMPLEMENTATION

1. RVPN specification shall mean RVPN technical specification, approved drawings/data sheets and LOA provisions applicable for the specific contract.
2. Acceptance criteria and permissible limits for certain tests are indicated at Annexure-III. For balance tests, site representative to verify the same with respect to RVPN specification, relevant Indian Standards and/or prevalent code of practice.
3. It is clarified that the tests indicated at column 2 of this FQP i.e. against column "Component/ Operation & Description of Test", are only generally required to be conducted. However, RVPN reserves the right to carry-out any additional tests at any stage if the situation so warrants.
4. RVPN site representative shall witness all the tests conducted by the contractor as mentioned in this FQP. However, in case of tests conducted in the RVPN approved lab, it is preferred to witness the tests in the lab itself, if possible.
5. RVPN shall approve testing laboratory before accepting the test results from the lab.
6. RVPN shall approve the sources for cement, coarse aggregate, fine aggregate & water before actual utilisation.
7. All the testing & measuring equipments used by the contractor for testing are required to be calibrated. A copy of valid calibration report shall be retained by RVPN as records.
8. Classification of foundation shall be approved by RVPN based on the joint inspection report and soil investigation reports.
9. Curing of concrete work should be continued for a minimum period of 10 days.
10. Zone-IV fine aggregate shall not be used for concreting work.
11. Identification and tractability records for various materials shall be maintained and retained in RVPN.
12. CEMENT
 - 12.1 Cement shall be procured from sources approved RVPN site and got tested at site on sample basis for specified acceptance tests as specified in this FQP at reputed third party lab approved by RVPN.
 - 12.2 The samples of cement for site testing shall be taken within three weeks of the delivery and all the tests shall be commenced within one week of sampling.
13. REINFORCEMENT STEEL
 - 13.1 Reinforcement steel shall be procured from the producers i.e. SAIL, TISCO, IISCO or Rashtriya Ispat Nigam, reinforcement steel shall be got tested at site on sample basis for specified acceptance tests as specified in this FQP at a reputed Third Party Lab approved by RVPN.
 - 13.2 The results of the testing of cement and reinforcement steel referred to in 12.1 and 13.1 above shall be got approved from RVPN site before cement and reinforcement steel are put to use. However, in exceptional cases to exigencies of work, RVPN site may authorise the contractor to use cement and reinforcement steel before the test results are received. However, in all such cases, if the test results subsequently received are found to be not complying with the specified acceptance criteria, the contractor shall have to dismantle and recast all such foundations cast with such non-conforming materials at his own cost. Confirmation to this effect shall be obtained from the contractor by the Project authorities before hand in all such cases.

ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FOUNDATION MATERIALS & CONCRETE

(A) CEMENT

Description of the tests	43 Grade cement as per IS:8112	53 Grade cement as per IS:12269	PPC as per IS:1489 (Part-1)	Low Heat Cement
(i) Fineness (min.)	225 m sq./Kg.	225 m sq./Kg.	300 m sq./Kg.	225 m sq./Kg.
(ii) Compressive Strength (min.)				
72 ± 1 hours	23 MPa	27 MPa	16 MPa	100 Kgf/cm.sq.
168 ± 2 hours	33 MPa	37 MPa	22 MPa	160 Kgf/cm.sq.
672 ± 4 hours	43 MPa	53 MPa	33 MPa	350 Kgf/cm.sq.
(iii) Initial Setting Time (minimum)	30 minutes	30 minutes	30 minutes	30 minutes
(iv) final setting Time (maximum)	600 minutes	600 minutes	600 minutes	600 minutes
(v) Soundness (Le chatelier Method)	Maximum 10 mm expansion	Maximum 10 mm expansion	Maximum 10 mm expansion	Maximum 10 mm expansion
(vi) Heat of hydration (max.)	-	-	-	Max. 65 Cal/gm for 7 days & max. 75 cal/gm for 28 days.
(vii) Chemical composition	As per IS	As per IS	As per IS	As per IS

(B) COARSE AGGREGATE

(i) Sieve Analysis

IS SIEVE DESIGNATION	PERCENTAGE PASSING FOR GRADED AGGREGATE OF NOMINAL SIZE	
	40 mm	20 mm
40 mm	95 TO 100	100
20 mm	30 TO 70	95 TO 100
10 mm	10 TO 35	25 TO 55
4.75 mm	0 TO 5	0 TO 10

(ii)	Flakiness Index	Not to exceed 25%
(iii)	Crushing Value	Not to exceed 45%
(iv)	Soundness of aggregate applicable for concrete works subject to frost action	Loss of weight after 5 cycle not to exceed 12% when tested with Sodium sulphate and 18% when tested with magnesium sulphate
(v)	Deleterious material	Not to exceed 5% of the weight of aggregate

(C) FINE AGGREGATE

(i)	Sieve Analysis	Shall conform to Zone I, Zone II or Zone III
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IS Sieve designation	Percentage Passing for			
	Grading Zone-I	Grading Zone-II	Grading Zone-III	Grading Zone-IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100

600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8.30	12.40	15-50
150 micron	0-10	0-10	0-10	0-15

(ii) For guidance of adjusting the quantity in mix of concrete, the following table may be used.

Moisture Content %	Bulking % of volume
2	15
3	20
4	25
5	30

(iii)	Silt content Test	Shall not exceed 8% by volume
(iv)	Deleterious Materials	Total deleterious material shall not be more than 5% by weight.

(D) REINFORCEMENT STEEL As per relevant Indian Standard

(E) CONCRETE CUBE TEST

For nominal (Volumetric) concrete mixes, compressive strength for 1:1.5: 3 (cement: Sand: Coarse aggregate) concrete shall be 265 Kg/cm sq. for 28 days and for 1:2:4 nominal mix, it shall be 210 Kg/cm sq..

(F) ACCEPTANCE CRITERIA BASED ON 28 DAYS COMPRESSIVE STRENGTH FOR NOMINAL MIX CONCRETE

- (i) The average of the strength of three specimen be accepted as the compressive strength of the concrete, provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.
- (ii) If the actual average strength of accepted sample exceeds specified strength by more than 30%, the Engineer-in-charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of specified strength, it will be restricted to 30% only for computation of strength.
- (iii) If the actual average strength of accepted sample is equal to or higher than specified strength upto 30%, then strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
- (iv) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate by the method of linear interpolation at the discretion of Engineer-in-charge.
- (v) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-charge shall reject the defective portion of work represented by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken at the risk and cost of contractor. If, however, the Engineer-in-charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the contractor.

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

1.	DETAILED SURVEY & ALIGNMENT								
a)	Field Survey	Contractor	-	-	-	Route map & measurement schedule	Contractor		
b)	Plotting of Route	Contractor	-	-	-	Field book, RVPN Technical specification & Geographical maps	Contractor		
c)	Profile Plotting	Contractor	-	-	-	Field Book	Contractor		
d)	Tower Spotting	AE	-	EE	-	Tower Spotting Data & RVPN technical specification	Contractor	SE	CE
e)	Tower Schedule	AE	-	EE	-	Approved profile drawings & route alignment	Contractor	SE	CE
2.	CHECK SURVEY								
a)	Bisection of Angle/accuracy of alignment	SVR/JE	-	-	AE	Approved profile drawings & route alignment	Contractor		
b)	Check for profile levels and electrical & other clearances	SVR/JE	-	-	AE	Approved profile drawings	Contractor		
c)	Check for span marking and lengths	SVR/JE	-	-	AE	Approved profile drawings & RVPN technical specification	Contractor		
d)	Check for tower type and position as per site conditions	JE	-	-	AE	Approved profile drawings & RVPN technical specification	Contractor		
e)	Estimation of benching & Revetment volumes (as per site conditions, where- ever required)	Contractor/AE	-	-	--	Approved profile drawings, check survey & RVPN technical specification	Design to be submitted by contractor	SE(P&P)	CE (PPM)
f)	Final profile & tower schedule	AE	-	EE	-	Approved profile drawings & RVPN technical specification	Contractor	SE	CE
3.	SOIL INVESTIGATION								
A)	AT NORMAL LOCATIONS	All other than angle, river crossing & special locations							
i.	Borelog	JE	-	-	AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
ii.	Ground Water level	Contractor	-	JE	JE	-	-		
iii.	Classification of foundations (based on soil classification, liquid limit, swell index & ground water level)	400 kV Design Circle on the basis of the soil investigation report.				RVPN technical specification & relevant IS	Contractor	SE(P&P)	CE(PPM)
B)	AT ANGLE TOWER LOCATIONS (min. one location in 4 Kms. Stretch)	All angle tower locations							

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

i.	Standard Penetration Test	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor		
ii.	Gradation	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
iii.	Rock drilling wherever applicable	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
iv.	Chemical Analysis of sub-soil	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
v	Bearing Capacity	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor		
vi.	Classification of foundation	400 kV Design Circle on the basis of soil investigation report				RVPN technical specification & relevant IS	Contractor	SE(P&P)	CE(PPM)
C)	AT RIVER CROSSING AND SPECIAL LOCATIONS	At river crossing & special locations							
i.	Standard Penetration Test	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor		
ii.	Gradation	JE(C)	-	-	AE(C)	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
iii.	Rock drilling wherever applicable	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
iv.	Ground Water Level	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor		
v	Chemical Analysis of sub-soil	JE(C)	-	-	AE(C)	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
vi.	Dynamic Cone Penetration Test	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
vii.	Vane Shear Test (Where UDS is not possible)	JE(C) & JE	-	-	AE(C) & AE	RVPN technical specification & relevant IS	Contractor/ Lab. approved by RVPN		
viii.	Bearing Capacity	JE(C)	-	-	AE(C)	RVPN technical specification & relevant IS	Contractor		
ix.	Scouring depth & Velocity of river	JE(C)	-	-	AE(C)	RVPN technical specification & relevant IS	Contractor		
x.	Highest flood level	JE(C) &	-	-	AE(C) &	RVPN technical specification &	Contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

		JE			AE	relevant IS			
xi.	Classification of foundations	400 kV Design Circle on the basis of soil investigation report				RVPN technical specification & relevant IS	Contractor	SE(P&P)	CE(PPM)
D)	SOIL RESISTIVITY As per Requirement of PTCC: Every 2-3 km and wherever soil type changes	JE	-	-	AE	IS:2131, IS:2720 and RVPN specification	Contractor		
E)	TEST ON SOIL AND ROCK SAMPLES								
a)	Tests on undisturbed and disturbed samples	All angle tower locations, river crossing and special Locations				IS:2131, IS:2720 & RVPN specification	Contractor/ Lab. approved by RVPN		
i.	Visual and engineering classifications	JE(C)	-	-	AE(C)				
ii.	Sieve Analysis and Hydrometer Analysis	JE(C)	-	-	AE(C)				
iii.	Liquid, Plastic and Shrinkage limits	JE(C)	-	-	AE(C)				
iv.	Specific gravity	JE(C)	-	-	AE(C)				
v.	Chemical analysis	JE(C)	-	-	AE(C)				
vi.	Swell pressure and free swell index determination	JE(C)	-	-	AE(C)				
vii.	Proctor compaction test	JE(C)	-	-	AE(C)				
b)	Tests on undisturbed and disturbed samples	All angle tower locations, river crossing and special Locations				IS:2131, IS:2720 & RVPN specification	Contractor/ Lab. approved by RVPN		
i.	Bulk density & moisture content	JE(C)	-	-	AE(C)				
ii.	Relative density(for sand)	JE(C)	-	-	AE(C)				
lii.	Unconfined compression Test	JE(C)	-	-	AE(C)				
iv.	Box Shear Test (in case of sand)	JE(C)	-	-	AE(C)				
v.	Tri-axial shear Test	JE(C)	-	-	AE(C)				
	a. Unconsolidated un-drained test	JE(C)	-	-	AE(C)				
	b. Consolidated drained test	JE(C)	-	-	AE(C)				
	c. Consolidation	JE(C)	-	-	AE(C)				
c)	Tests on Rock	All angle tower locations, river crossing and special Locations				IS:2131, IS:2720 & RVPN specification	Contractor/ Lab. approved by RVPN		
i.	Visual Classification	JE(C)	-	-	AE(C)				
ii.	Moisture Content, Porosity and density	JE(C)	-	-	AE(C)				

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

iii.	Specific Gravity	JE(C)	-	-	AE(C)				
iv.	Hardness	JE(C)	-	-	AE(C)				
v.	Stake durability	JE(C)	-	-	AE(C)				
vi.	Unconfined compression test	JE(C)	-	-	AE(C)				
vii.	Point Load strength index	JE(C)	-	-	AE(C)				
viii.	Deformability test	JE(C)	-	-	AE(C)				
d)	Chemical analysis of sub-soil water	JE(C)	-	-	AE(C)	IS:2131, IS:2720 & RVPN specification	Contractor/ Lab. approved by RVPN		
e)	Classification of foundation	400 kV Design on the basis of soil investigation report.				RVPN specification & relevant ISS.	Contractor/ Lab. approved by RVPN	SE(P&P)	CE(PPM)
4.	CHECKING OF FOUNDATION MATERIALS								
A)	CEMENT	Review of all MTC's and one sample for every 200 MT or part thereof from each source.							
i.	Fineness	AE	-	-	EE	IS:456, IS:4031, IS:8112, IS:12269, IS:1489 & RVPN specification	MNIT, Jaipur/ MBM Engineering College, Jodhpur/ Field testing station Gol, Jaipur/Lab. approved by RVPN	Results to be checked and acceptance given by EE(CQC)	HOD (CIVIL)
ii.	Compressive Strength	AE	-	-	EE				
iii.	Initial & Final setting time	AE	-	-	EE				
iv.	Soundness	AE	-	-	EE				
v.	Heat of Hydration for low heat cement (not applicable for OPC & PPC)	AE	-	-	EE				
vi.	Chemical composition of cement	One sample per lot of 100 MT or part thereof from each source for MTCs				IS:456, IS:4031, IS:8112, IS:12269, IS:1489 & RVPN specification	Manufacturer	Review of manufacturers test certificates by EE(CQC)	
B)	COARSE AGGREGATES	One sample per lot of 200 cubic metre or part thereof from each source for each size							
i.	Determination of Particle size (Sieve Analysis)	Assistant Engineer	-	Executive Engineer	-		MNIT, Jaipur/ MBM Engineering College, Jodhpur/ Field testing station Gol, Jaipur/Lab. approved by RVPN	Each source to be approved by RVPN on the basis of review and acceptance of test result by EE (CQC)	HOD (CIVIL)
ii.	Flakiness Index		-		-				
iii.	Crushing Value		-		-				
iv.	Soundness of Aggregate**		-		-				
v.	Prescience of deleterious materials		-		-				

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

C)	FINE AGGREGATE	One sample per lot of 200 cubic metre or part thereof from each source							
i.	Gradation/Determination of Particle size (Sieve Analysis)	Assistant Engineer	-	Executive Engineer	-	IS:383, IS:2386, IS4031, IS:236, IS:456 and RVPN specification	MNIT, Jaipur/ MBM Engineering College, Jodhpur/ Field testing station Gol, Jaipur/Lab. approved by RVPN	Each source to be approved by RVPN on the basis of review and acceptance of test result by EE(CQC)	HOD (CIVIL)
ii.	Silt Content Test		-		-				
iii.	Presence of deleterious materials		-		-				
D)	WATER	JE	--	AE	EE	Potable water	Contractor		
E.	REINFORCEMENT STEEL							EE(CQC)	HOD (CIVIL)
i.	Identification & size			JE	AE	IS:432, IS:1139, IS:1786 & RVPN specification- Random	Contractor		
ii.	Chemical Analysis Test	One sample per heat				IS:432, IS:1139, IS:1786 & RVPN specification	Manufacturer	Review of manufacturers test certificates by RVPN	
iii.	Tensile Test	AE	--	--	--	IS: 432, IS: 1139, IS: 1786 & RVPN specification. Review of MTC's. One sample of each diameter of steel re-bar from lot of 200 MT or part thereof from each source	MNIT, Jaipur/ MBM Engineering College, Jodhpur/ Field testing station Gol, Jaipur/Lab. approved by RVPN	Review of test certificates as per lab test result and acceptance by EE(CQC)	
iv.	Yield Stress/ proof stress								
v.	Percentage Elongation								
vi.	Bend/Re-bend Test	JE	--	AE	-	IS:432, IS:1139, IS:1786 & RVPN specification. Review of MTC's. One sample of each diameter of steel re-bar from lot of 200 MT or part thereof from each source	MNIT, Jaipur/ MBM Engineering College, Jodhpur/ Field testing station Gol, Jaipur/Lab. approved by RVPN	Review of test certificates as per lab test result and acceptance by EE(CQC)	
vii.	Reverse Bend Test for HDS wire	JE	--	AE	--	IS: 432 & RVPN specification. Review of MTC's. One sample of each diameter of steel re-bar from lot of 200 MT or part thereof from each source	MNIT, Jaipur/ MBM Engineering College, Jodhpur/ Field testing station Gol, Jaipur/Lab.	Review of test certificates as per lab test result and acceptance by EE(CQC)	

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

							approved by RVPN		
F.	EARTHING MATERIALS								
i.	Identification, cleanliness & Galvanising defects	LM	JE	-	AE	RVPN approved drawing & specification	Contractor		
5.	TOWER FOUNDATION								
A)	BEFORE EXCAVATION								
i.	Checking of pegs condition as per line and alignment	SVR	--	JE	AE	IS:4019, IS:5613 & RVPN approved drawings/ specification.	Contractor		
ii.	Checking of pit marking as per drawing & RL	SVR	--	JE	AE	IS:4019, IS:5613 & RVPN approved drawings/ specification.	Contractor		
B)	EXCAVATION	Each location							
i.	Dimensional conformity	JE	-	AE	EE	IS:4091, IS:5613 & RVPN approved drawings/ specification	Contractor		
ii.	Verticality & square ness of each pit	LM	-	JE	AE	IS:4091, IS:5613 & RVPN approved drawings/ specification	Joint inspection by RVPN and contractor		
iii.	Verification of classification of foundation (in case of any change, if required in classification, recommendation shall be prepared by EE and the same shall be submitted to the SE(D) for approval of re-classification)	JE	-	AE	EE	IS:4091, IS:5613 & RVPN approved drawings/ specification	Joint inspection by RVPN and contractor		
C.	Stub & template	100% on each location							
i.	Identification & Assembly	LM	-	JE	-	RVPN approved drawings/ specification	Joint inspection by RVPN and contractor		
ii.	Template level, width & diagonal	JE	-	AE	EE	RVPN approved drawings/ specification	Joint inspection by RVPN and contractor		
iii.	Tightening of all bolts & nuts of template, stubs and cleats	LM	-	JE	AE	RVPN approved drawings/ specification	Joint inspection by RVPN and contractor		
iv.	Stub setting	JE	-	AE	EE	RVPN approved drawings/ specification	Joint inspection by RVPN and contractor		
D)	P.C.C. PADDING	JE	-	-	AE	IS:456 and RVPN approved foundation drawings & specification	Joint inspection by RVPN and contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

E)	STAGING FOR RAISED CHIMNEY								
i.	Check durability, strength & soundness of staging, joints adequacy of its joints & specific levels	JE	-	-	AE	RVPN specification	Joint inspection by RVPN and contractor		
F)	SHUTTERING (Formwork)	The newly fabricated former boxes shall be approved by EE before use.							
i.	Check for materials, breakage or damage	LM	-	--	JE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
ii.	Check for plumb alignment, parallelism, square ness and equidistance from stub	LM	-	--	JE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
iii.	Dimensional check	JE	-	-	AE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
iv.	Check for level & height	LM	-	JE	AE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
v.	Check for rigidity of frame/tightness	LM	-	JE	AE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
vi.	Cleaning and oiling	LM	-	JE	AE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
vii.	Diagonal bracing if required as per drawings/site conditions	LM	-	JE	AE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
viii.	Checking of joints to avoid undue loss of cement slurry	LM	-	JE	AE	RVPN specification/ approved drawings	Joint inspection by RVPN and contractor		
G.	PLACEMENT OF REINFORCEMENT STEEL	The reinforcement of the first tower of all types of foundations (type of tower without & with extension and type of soil) shall be checked by AE(C) to be nominated by CE/SE (Civil).							
i.	Check the steel bars for rust, cracks, surface flaws, laminate etc. (Visual check)	LM	-	JE	AE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
ii.	Check as per the bar bending schedule before placement of concrete	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

iii.	Check cutting tolerance for bars as per check list/ drawings. Check whether all the bent bars and lap lengths are as per approved bar bending schedule	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
iv.	Check whether all joints & crossing of bars are tied properly with right gauge & annealed wire as per specification	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
v.	Check for proper cover distance, spacing of bars, spacers & chairs after the reinforcement cage has been put inside the formwork	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
vi.	Check whether lapping of bars are tied properly with right gauge and annealed wire as per specification.	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
H.	PILE FOUNDATION (additional Testes) (for normal tower foundations)	Each pile group						Checklist to be prepared and signed jointly	
i.	Checking of centre line of pile group	SVR	JE	-	AE	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
ii.	Check pile location	SVR	JE	-	AE	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
iii.	Temporary casing tube & permanent liner, also check thickness of liner material (if applicable)	JE	-	-	AE	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
iv.	Bentonite slurry (if applicable)	JE	-	-	AE	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
v.	Pile depth, level, size and alignment	JE	-	-	AE	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
vi.	Chipping of pile head	JE	-	-	AE	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

vii.	Standard Penetration test	JE(C)	-	-	AE(C)	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
viii.	Pile load testing	AE(C)	-	-	EE(C)	IS:2911 & RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor	SE(C)	CE(C)
ix.	Anchor bolts if applicable	100% on each location						Check list to be prepared and signed jointly	
a.	Level centre to centre distance of bolts	SVR	-	JE	AE	RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
b.	Visual Check for galvanising	LM	-	JE	AE	RVPN approved pile foundation drawings/specification	Joint inspection by RVPN and contractor		
6.	CONCRETING								
A)	BATCHING, MIXING & PLACING OF CONCRETE AND COMPACTION	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
B)	FIXING OF CHIMNEY COLUMN Check for width/length, square ness, parallelism & equidistance from stub	JE	-	AE	EE	IS:456 and RVPN specification/approved drawings	Joint inspection by RVPN and contractor		
C)	CONCRETE TESTING								
i.	Slump Test (One sample per location)	JE	-	AE	EE	IS:456, IS:516, IS:1199 and RVPN specification	Contractor		
ii.	Check for quality & quantities for cement, fine aggregate, coarse aggregate and water while batching	JE	-	AE	EE	IS:456, IS:516, IS:1199 and RVPN specification	Contractor		
D)	CHECK FINISHING, DIMENSIONAL CONFORMITY AND WORKMANSHIP BEFORE & AFTER BOX REMOVAL	JE	-	AE	EE	IS:456, IS:516, IS:1199 and RVPN specification	Contractor		
E)	BACKFILLING	JE	-	AE	EE	RVPN specification	Contractor		
i.	Check for thickness of layer & watering	JE	-	AE	EE				
ii.	Check for compaction & ramming	JE	-	AE	EE	RVPN specification	Contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

F.	REVTMENT								
i.	Size of stone for Revetment (Stones with round surface shall not be used)	JE	-	-	AE	RVPN specification & approved drawings	Contractor		
ii.	Check for Weep holes and bond stones in Revetment	JE	-	-	AE	RVPN specification/approved drawings/IS: 1597	Contractor		
G)	COPING	JE	-	-	AE	RVPN specification	Contractor		
H)	CURING	LM	-	JE	AE	RVPN specification	Contractor		
I)	EARTHING (pipe or counter poise type)	JE	-	AE	EE	IS:5613 and RVPN specification	Contractor		
J)	CONCRETE CUBE TESTING								
i.	Compressive Strength a) One sample for each locations (one sample consists of min. 3 test cubes for 28 days strength) b) For pile foundation one sample for each pile	JE	-	AE	EE	IS:1199, IS:456, IS:516 and RVPN specification	Lab. approved by RVPN	Review and acceptance of test certificate by EE(CQC)	HOD (CIVIL)
ii.	Compressive Strength for concrete of pile cap, beams, chimney etc. One sample for every 20 Cu.m. of concrete or part thereof for each day of concreting	JE	-	AE	EE	IS:1199, IS:456, IS:516 and RVPN specification	Lab. approved by RVPN	Review and acceptance of test certificate by EE(CQC)	HOD (CIVIL)
7.	TOWER ERECTION								
A)	MATERIAL CHECKING								
i.	Visual checking of tower members for damage, cleanliness, galvanising and stacking	LM	-	-	JE	IS:5613 and RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
ii.	Visual checking of galvanised bolts and nuts, step bolts, D-Shackles, U-bolts, spring washers & enameled plates	LM	-	-	JE	IS:5613 and RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
B)	ERECTION OF SUPER STRUCTURE	100% on each location							
i.	Tightness of bolts, identification, cleanliness and galvanising	LM	-	-	JE	RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

ii.	Punching of tightened bolts	LM	-	-	JE	RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
iii.	Checking of assembly and verticality	JE	-	AE	EE	RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
iv.	Tack welding	JE	-	AE	EE	RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
v.	Tower footing resistance	JE	-	AE	EE	RVPN approved drawings/specification	Joint Inspection by RVPN and contractor	SE	
vi.	Fixing of danger plate, number plate, phase plates & circuit plate as applicable	JE	-	AE	EE	RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
8.	LINE STRINGING								
A)	Insulator Checking								
i.	Visual checking of Insulators (Identification, cleanliness, glazing, cracks & white spots)	LM	-	-	JE	IS:5613 & RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
ii.	IR Measurement of 5% quantity of disc insulator per tower	LM	-	JE	AE	For each disc insulator more than 50 mega ohms with 5 kV Megger.	Joint Inspection by RVPN and contractor		
B)	VISUAL CHECKING OF CONDUCTOR AND EARTH WIRE	LM	-	JE	AE	IS:5613 & RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
C)	VISUAL CHECKING OF HARDWARE FITTINGS (identification, cleanliness, galvanising and mechanical damages)					IS:5613 & RVPN approved drawings/specification	Joint Inspection by RVPN and contractor		
i.	Identification, cleanliness & packing	LM	-	JE	AE				
ii.	Damage of conductor & earth wire	LM	-	JE	AE				
iii.	Drum rubbing against ground or any metal part	LM	-	JE	AE				
D)	CONDUCTOR & EARTH WIRE STRINGING	Entire route							
i.	Initial conductor position	JE	-	AE	-	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10
ii.	Check for temperature	JE	-	AE	-	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		
iii.	Final conductor & earthwire position	AE	-	--	EE	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		
a.	Electrical Clearances	AE	-	-	EE				
b.	Sag/Tension for conductor and earthwire	AE	-	-	EE				
c.	Joints in conductor and earthwire	AE	-	-	EE				
iv.	Jumpering	LM	-	JE	AE	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		
v.	Fixing of pilot insulator string (if any)	LM	-	JE	AE	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		
9.	FINAL CHECKING								
a)	Check for the completion of back-filling & leftover materials	JE	-	AE	EE	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		
b)	Fixing of ACD & all tower accessories	JE	-	AE	EE	IS:5613 & RVPN approved SAG & Tension charts and specifications	Joint Inspection by RVPN and contractor		
c)	Tightening, punching and tack welding of bolts	JE	-	AE	EE				
d)	Final ground and electrical clearances	JE	AE	-	EE				
e)	Earthing	JE	AE	-	EE				
10.	MEGGAR TEST	100% by EE				RVPN latest pre-commissioning procedures	Joint Inspection by RVPN and contractor	CE	
11.	FINAL TESTING & PRE-COMMISSIONING ON LINE	100% by EE				RVPN latest pre-commissioning procedures	Joint Inspection by RVPN and contractor	CE	

Notes:

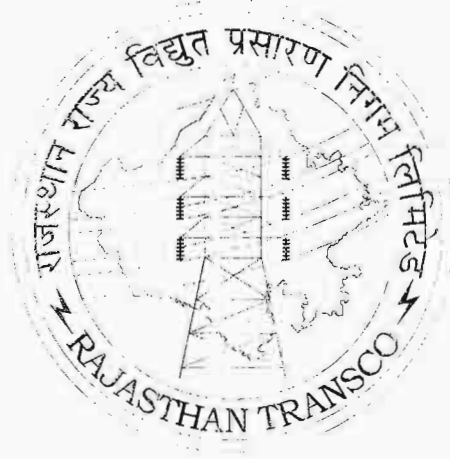
1. In case of testing of samples in MNIT/MBM/RVPN civil lab/ Field testing station GoI Jaipur witnessing is not required. For other approved lab. Testing shall be witnessed by JE(C)/AE(C).
2. The testing lab. should be located in Rajasthan only. In case of Soil Investigation, no lab witness is required for Bore Log samples.

S No.	Component/operation & Description of tests	Sampling/Checking/Witnessing				Reference documents & acceptance norms	Testing agency	Accepting, if test results are within permissible limits.	Deviation dispositioning authority
		100%	40 % to 50%	20% to 25%	8% to 10%				
1	2	3	4	5	6	7	8	9	10

3. The contractor may set up quality control lab. with calibrated equipment (not older than one year) for testing of concrete cube/coarse & fine aggregates, to be witnessed by JE/AE.
4. Officer nominated by civil wing shall witness the first stub setting work for each type of foundation.
5. Samples at site shall be witnessed by JE/AE. Samples shall be sealed in their presence and identified with reference to location No. etc. as applicable and signed by JE/AE and the contractor's representative.
6. Approval shall be necessary only where mentioned in the above plan. The decision for such items in respect of verification or acceptance shall be taken by the nominated inspecting authority.
7. **Abbreviations used -**

LM	Line Man	AE (C)	Assistant Engineer (Civil)	SE (C)	Superintending Engineer (Civil)
SVR	Surveyor	EE	Executive Engineer (TCC)	SE (D)	Superintending Engineer (P&P)
JE	Junior Engineer (TCC)	EE (C)	Executive Engineer (Civil)	CE (Civil)	Chief Engineer (Civil)
JE(C)	Junior Engineer (Civil)	EE (CQC)	Executive Engineer (Civil Quality Control)	CE (PPM)/ (T&C)	Chief Engineer (PPM)/ (T&C)
AE	Assistant Engineer (TCC)	SE	Superintending Engineer (TCC)	HOD (Civil)	Head of Department (Civil)

Rajasthan Rajya Vidyut Prasaran Nigam Limited



Sub section IV

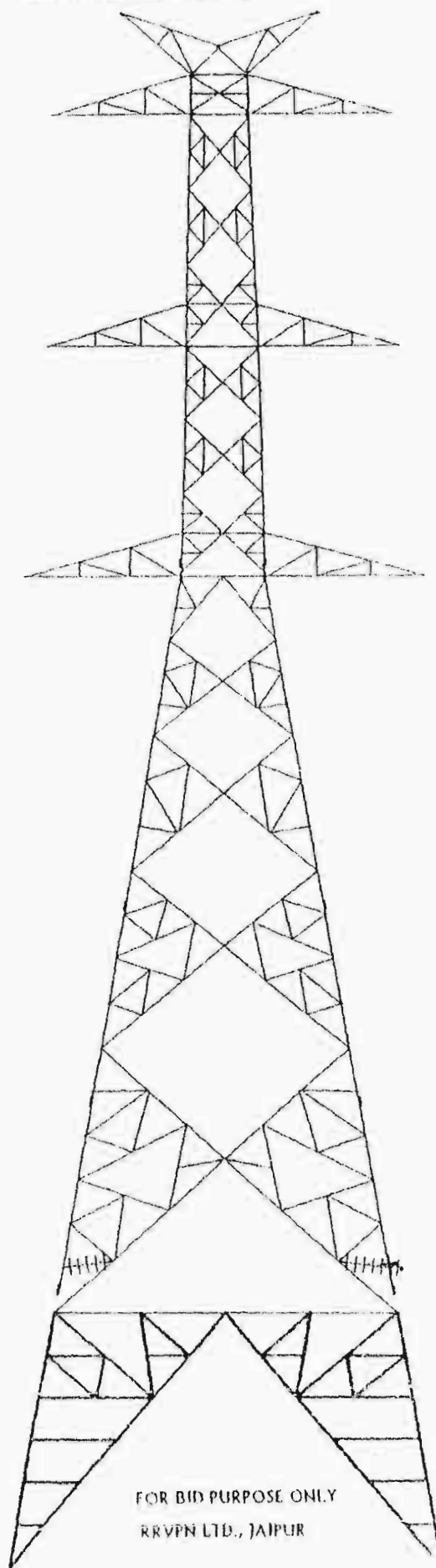
(Part of Volume II)

DRAWINGS

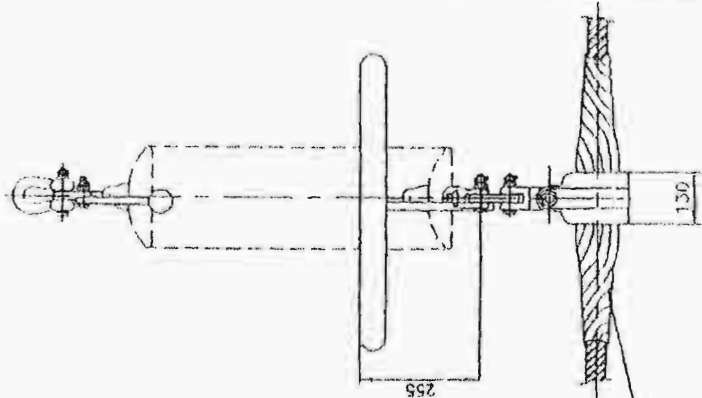
DRAWINGS

S.NO.	DESCRIPTION	DRAWING NO.
1.	SINGLE LINE DIAGRAM OF 400 kV DOUBLE CIRCUIT TOWER	SE/400 kV Purchase/001
2.	400 kV SINGLE SUSPENSION STRING FOR TWIN MOOSE ACSR CONDUCTOR.	SE/400kV Purchase/002
3.	400 kV DOUBLE SUSPENSION STRING FOR TWIN MOOSE ACSR CONDUCTOR.	SE/400kV Purchase/003
4.	400 kV SINGLE SUSPENSION STRING FOR TWIN MOOSE ACSR CONDUCTOR (PILOT TYPE).	SE/400kV Purchase/004
5.	400 kV SINGLE TENSION STRING FOR TWIN MOOSE ACSR CONDUCTOR.	SE/400kV Purchase/005
6.	400 kV DOUBLE TENSION STRING FOR TWIN MOOSE ACSR CONDUCTOR.	SE/400kV Purchase/006
7.	NUMBER PLATE	SE/400kV Purchase/007
8.	DANGER PLATE	SE/400kV Purchase/008
9.	PHASE PLATE	SE/400kV Purchase/009
10.	BIRD GUARD	SE/400kV Purchase/010
11.	PIPE TYPE EARTHING	SE/400kV Purchase/011
12.	COUNTERPOISE EARTHING ARRANGEMENT	SE/400kV Purchase/012
13.	DETAILS FOR FLATS FOR EARTHING	SE/400kV Purchase/013
14.	STEP BOLT	SE/400kV Purchase/014
15.	EARTHING ATTACHMENT	SE/400kV Purchase/015
16.	ANTI CLIMBING DEVICE	SE/400kV Purchase/016
17.	ANTI THEFT FASTNER	SE/400kV Purchase/017

SINGLE LINE DIAGRAM OF 400 KV D/C TOWER



FOR BID PURPOSE ONLY
RRVPL LTD., JAIPUR



RRV PN LTD., JAIPUR

400 KV. SINGLE SUSPENSION STRING
FOR TWIN "MOOSE" ADSS CONDUCTOR.
UTS : 120 KN. (MIN.)

FIG. NO. - SE/400 W/ Purchase/002

- 1) ALL DIMENSIONS ARE IN MM.
- 2) SPRING WASHER ELECTRO GALVANIZED.
- 3) SLIPPING STRENGTH OF CLAMP : 20 TO 29 KN
- 4) BALL & SOCKET SIZE : 20 MM. AS PER IS-7439 (POT. 1)
- 5) ALL FERROUS PARTS NOT DIP GALVANIZED AS PER

RR/PNL SPECIFICATION

- 6) MIN. CORONA EXTINCTION VOLTAGE (DRY) 320 KV (RWS)
- 7) MAGNETIC POWER LOSS AT 500 AMP CONDUCTORS
CURRENT LESS THAN 1 WATT PER CLAMP ASSEMBLY
- 8) RIV AT 305 KV (DRY) BELOW 1000 MICROVOLTS
- 9) HARDWARE TOLERANCES ON LENGTH $\pm 2\%$
- 10) TOTAL WEIGHT OF HARDWARE FITTING : 32.8 KG (APPROX)
- 11) INSULATOR DISC TOLERANCES : ± 4 mm PER DISC
- 12) CONSTRUCTION AND OTHER DETAILS AS PER SPECIFICATION NO. 7.5
- 13) EXCEPT THE TOLERANCE SPECIFIED IN VARIOUS DIMENSIONS, BALANCE DIMENSIONS MAY BE SUBJECT TO ± 5 TOLERANCE

TECHNICAL DETAILS:

- 1) ALL DIMENSIONS ARE IN MM.
- 2) SPRING WASHER ELECTRO GALVANIZED.
- 3) SLEEVING STRENGTH OF CLAMP : 20 TO 25 KN.
- 4) BALL & SOCKET SIZE : 20 mm AS PER IS:2486(PART II)
- 5) ALL FERROUS PARTS HOT DIP GALVANIZED
AS PER RMPNL SPECIFICATION
- 6) MINICORONA EXTINCTION VOLTAGE (DRY) 320 KV (RMS).
- 7) MAGNETIC POWER LOSS AT 500 AMP CONDUCTOR
CURRENT LESS THAN 1 WATT PER CLAMP ASSEMBLY.
- 8) RIV AT 305 KV (RMS) (DRY) BELOW 1000 MICROVOLTS.
- 9) EXCEPT THE TOLERANCE SPECIFIED IN VARIOUS DIMENSIONS, BALANCE
DIMENSIONS MAY BE SUBJECT TO IS TOLERANCE
- 0) HARDWARE TOLERANCES ON LENGTH $\pm 2\%$
- 1) TOTAL WEIGHT OF HARDWARE FITTING : 58.7 KG (APPROX).
- 2) INSULATOR DISC TOLERANCES : ± 4 mm PER DISC
- 3) CONSTRUCTION AND OTHER DETAILS AS PER SPECIFICATION NO. 7.5

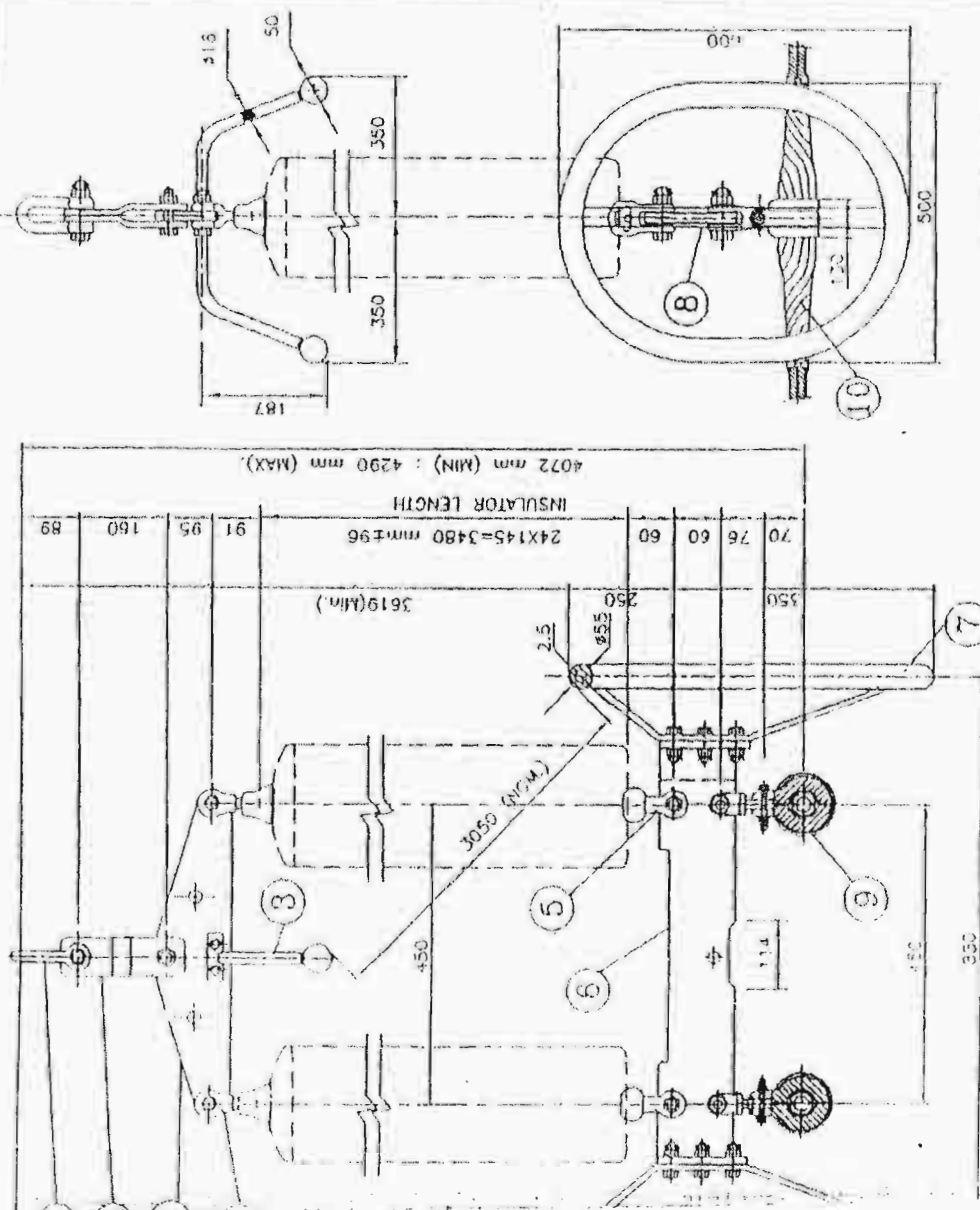
FOR BID PURPOSE ONLY

RRVPI LTD., JAIPUR

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400 KV. DOUBLE SUSPENSION STRING.
FOR TWIN "MOOSE" AC SR CONDUCTOR.
UTS : 240 KN. (MIN). •

DRG.NO.-SE/400 kV Purchase/003



STRAP	MILD STEEL F8-410, S2062	240 KN	1	EMI/CT-754
ROD	H. T ALUMINIUM ALLOY S5042/3063 S733	36 KG/mm2	2 SET	EMI/SCAD-677
CLAMP	ALUMINIUM ALLOY A-5 S517	120 KN	2	
W/RE	FORGED STEEL CL-M, S12004	120 KN	2	EMI/SC-429 F 0
	ALUMINIUM ALLOY S7400/3063 S733	15 KN	2 SET	EMI/SCP-2557
CONTROL RING	MILD STEEL F8-410, S2062	240 KN	1	EMI/19-1798
W/RE (ONE SIDE)	FORGED STEEL CL-M, S12004	120 KN	2	EMI/SC-373 F 1
	FORGED STEEL CL-M, S12004	120 KN	2	EMI/SC-387 F 1
W/RE (OTHER SIDE)	MILD STEEL F8-410, S2062	15 KN	2	EMI/14-5517
W/RE (OTHER SIDE)	MILD STEEL F8-410, S2062	240 KN	1	EMI/19-154
W/RE (OTHER SIDE)	FORGED STEEL CL-M, S12004	240 KN	1	EMI/SC-243 F 0
SUBSTITUTION	MATERIAL	QTY.		QTY. NO.
		QTY.		

TECHNICAL DETAILS:

- 1) ALL DIMENSIONS ARE IN mm.
- 2) SPRING WASHER ELECTRO GALVANIZED.
- 3) SLIPPING STRENGTH OF CLAMP : 20 KN TO 29 KN
- 4) BALL & SOCKET SIZE : 20 mm AS PER IS:2438 (PART-II)
- 5) ALL FERROUS PARTS HOT DIP GALVANIZED AS PER RRVPNL SPECIFICATION
- 6) MINICORONA EXTINCTION VOLTAGE (DRY) 320 KV (RMS)
- 7) MAGNETIC POWER LOSS AT 500 AMP CONDUCTOR CURRENT LESS THAN 2 WATTS PER CLAMP ASSEMBLY.
- 8) RIV AT 305 KV (RMS) (DRY) BELOW 1000 MICROVOLTS.
- 9) EXCEPT THE TOLERANCE SPECIFIED IN VARIOUS DIMENSIONS, BALANCED DIMENSIONS MAY BE SUBJECT TO IS TOLERANCE
- 10) HARDWARE TOLERANCES ON LENGTH $\pm 2\%$.
- 11) TOLERANCES ON INSULATOR DISC ± 4 mm.
- 12) TOTAL WEIGHT : 29.0 KG (APPROX).
- 13) CONSTRUCTION AND OTHER DETAILS AS PER SPECIFICATION NO. 7.5

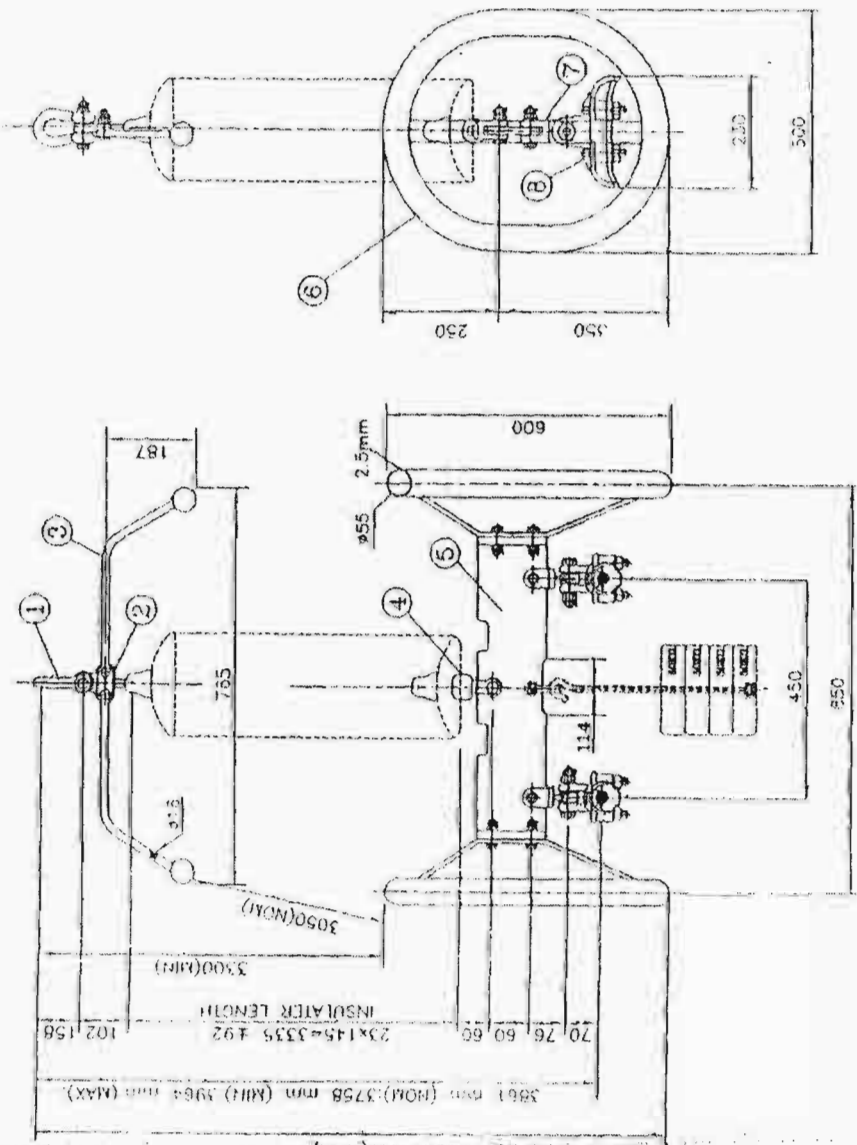
FOR BID PURPOSE ONLY

RRVPN LTD., JAIPUR

TITLE:-

400 KV. SINGLE SUSPENSION STRING TWIN
FOR "MOOSE" ACSR CONDUCTOR. (PILOT TYPE)
UTS : 120 KN.

DRG. NO. SE/400 KV Purchase.004



TECHNICAL DETAILS:

- 1) ALL DIMENSIONS ARE IN MM.
- 2) SPRING WASHER ELECTRO GALVANIZED.
- 3) SLIPPING STRENGTH OF CLAMP 153.14 KN. (MIN.)
- 4) BALL & SOCKET SIZE 20 mm. IS:2436 (PART-III)
- 5) ALL FERROUS PARTS ARE HOT DIP GALVANIZED AS PER RRVPN SPECIFICATION
- 6) MIN CORONA EXTINCTION VOLTAGE (DRY) 320 KV (RMS).
- 7) RV AT 305 KV (RMS) (DRY) BELOW 1000 MICROVOLTS
- 8) EXCEPT THE TOLERANCE SPECIFIED IN VARIOUS DIMENSIONS, BALANCE DIMENSIONS MAY BE SUBJECT TO IS TOLERANCE
- 9) HARDWARE TOLERANCES ON LENGTH $\pm 2\%$
- 10) TOLERANCES ON INSULATOR DISC ± 1 mm.
- 11) TOTAL WEIGHT 42 KG (APPROX).
- 12) CONSTRUCTION AND OTHER DETAILS AS PER SPECIFICATION NO. 7.5

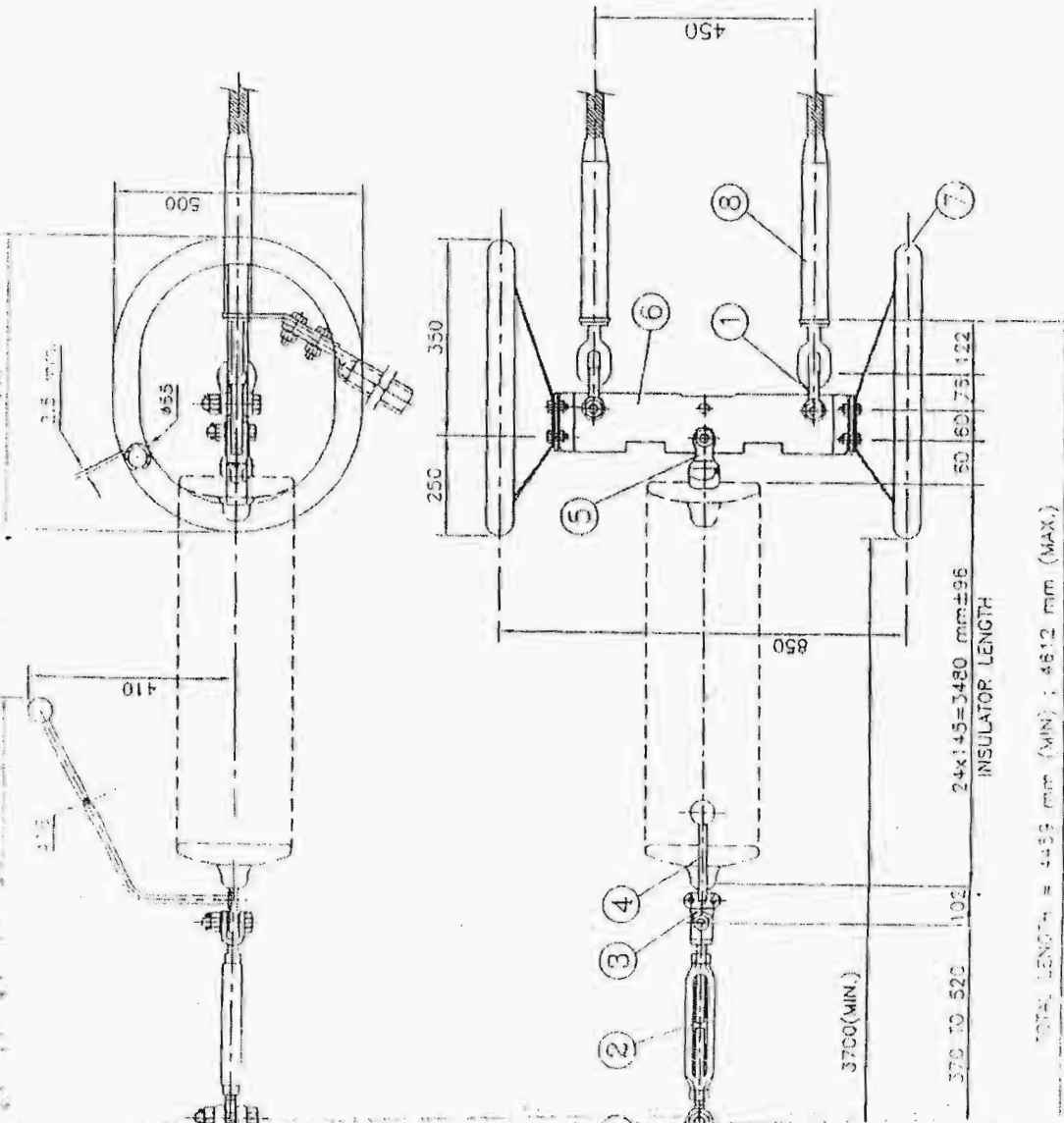
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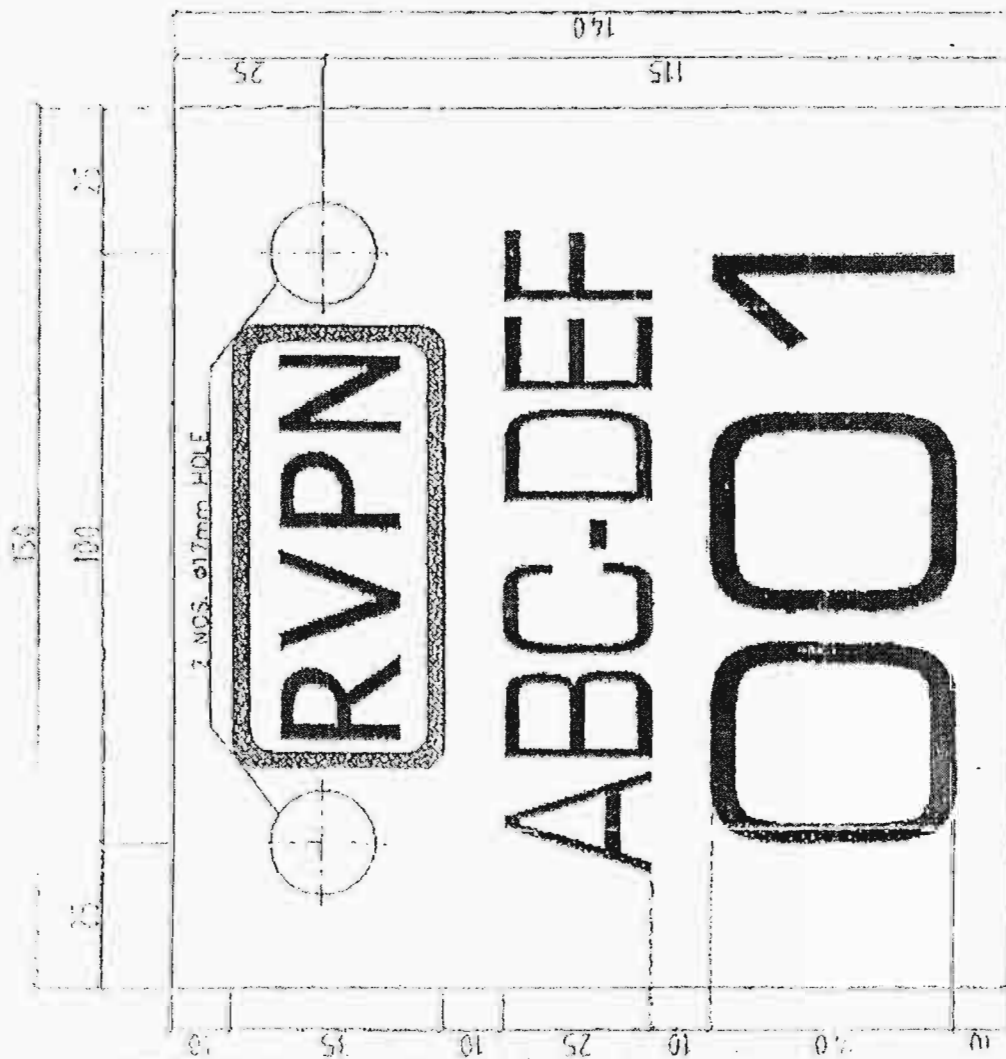
RRVPN LTD., JAIPUR

TITLE:-

400 KV. SINGLE TENSION STRING
FOR "MOOSE" ACSR CONDUCTOR.
UTS : 120 KN.

DRG.NO:SE/400 kV Purchase/005





NOTES:
THIS DRAWING IS ALSO APPLICABLE FOR 11KV S/C & D/C
TRANSFORMER LINE FROM CHOLPUR (OPTS) TO NEERAPURA
(JAMNAR) AGAINST TENDER SPEC. NO. RVN/2N/THY/78-197

LIST OF BOLTS & NUTS	
SIZE	QTY.
M-16x35MM LONG	2
LEAD WASHER 1MM THK.	2
SPRING WASHER	2

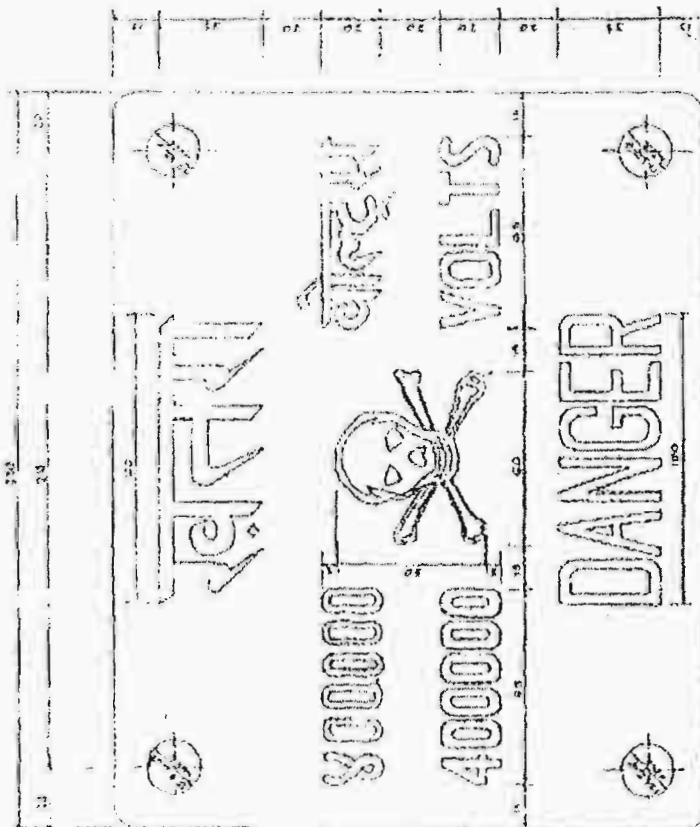
NUMBER PLATE

BID PURPOSE ONLY

RVPN LTD. JAIPUR

DRG No. SE/400 KV Purchase/007

NOTES:
1. THE USER SHALL BE RESPONSIBLE FOR THE
PROVISION OF THE NECESSARY MATERIALS
AND THE USER SHALL BE RESPONSIBLE FOR THE
PROVISION OF THE NECESSARY MATERIALS
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AND THE USER SHALL BE RESPONSIBLE FOR THE
PROVISION OF THE NECESSARY MATERIALS



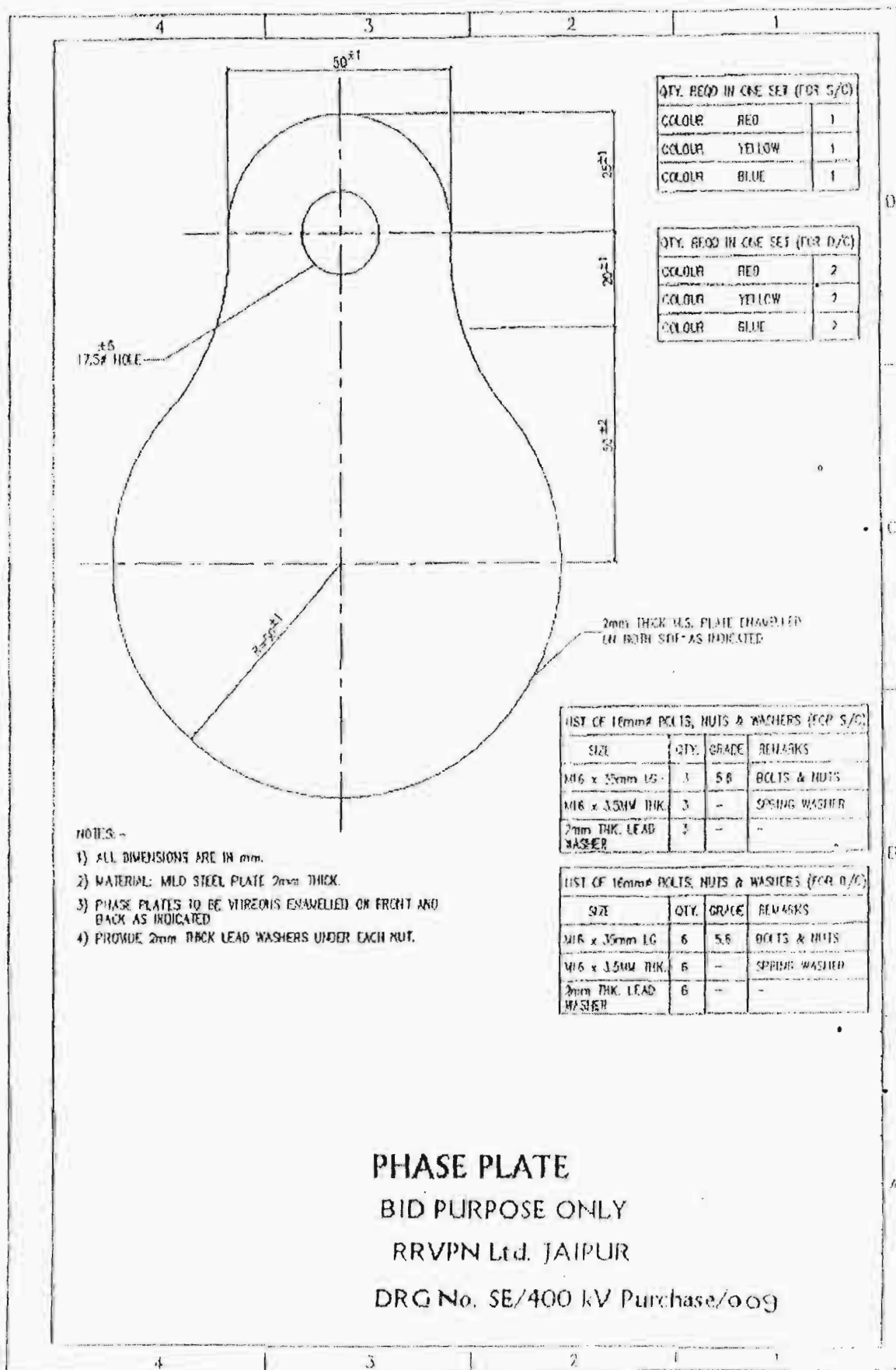
NOTES:-
 1. ALL THE DIMENSIONS ARE IN MM.
 2. THE PLATE IS TO BE MADE OF ALUMINUM OR STEEL.
 3. THE PLATE IS TO BE PAINTED IN WHITE COLOR.
 4. THE PLATE IS TO BE MARKED WITH THE FOLLOWING DETAILS:-
 5. A. DANGER
 6. B. 800000 VOLTS
 7. C. 400000 VOLTS
 8. D. वोल्ट
 9. E. SKULL AND CROSSBONES SYMBOL
 10. F. DANGER PLATE
 11. G. THE PLATE IS TO BE MADE OF ALUMINUM OR STEEL.
 12. H. THE PLATE IS TO BE PAINTED IN WHITE COLOR.
 13. I. THE PLATE IS TO BE MARKED WITH THE FOLLOWING DETAILS:-

DANGER PLATE

BID PURPOSE ONLY

RRVPN Ltd. JAIPUR

DRG No. SE/400 KV Purchase/008

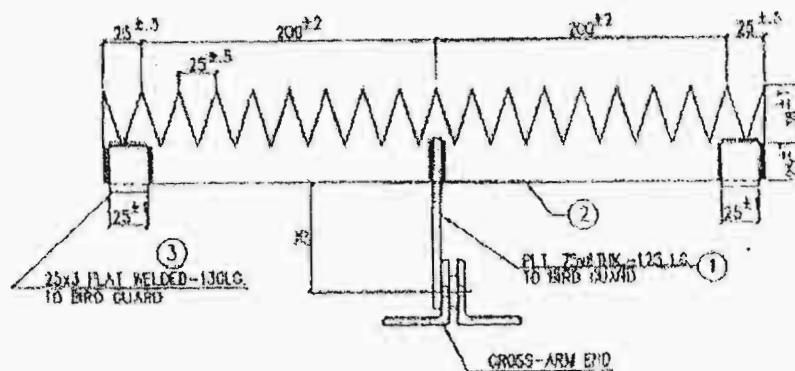


PHASE PLATE

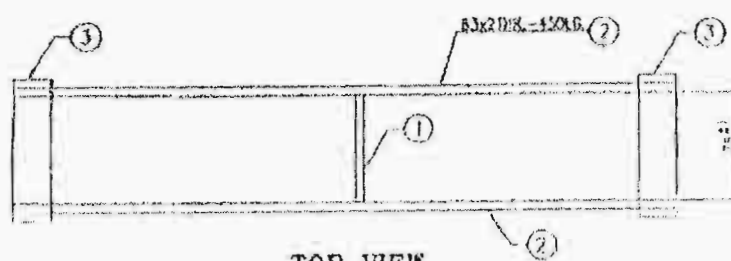
BID PURPOSE ONLY

RRVPN Ltd. JAIPUR

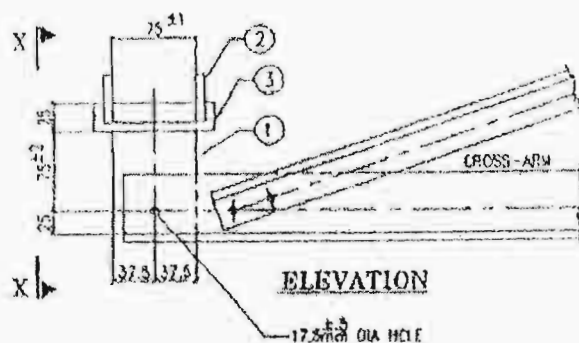
DRG No. SE/400 kV Purchase/009



VIEW X-X



TOP VIEW



ELEVATION

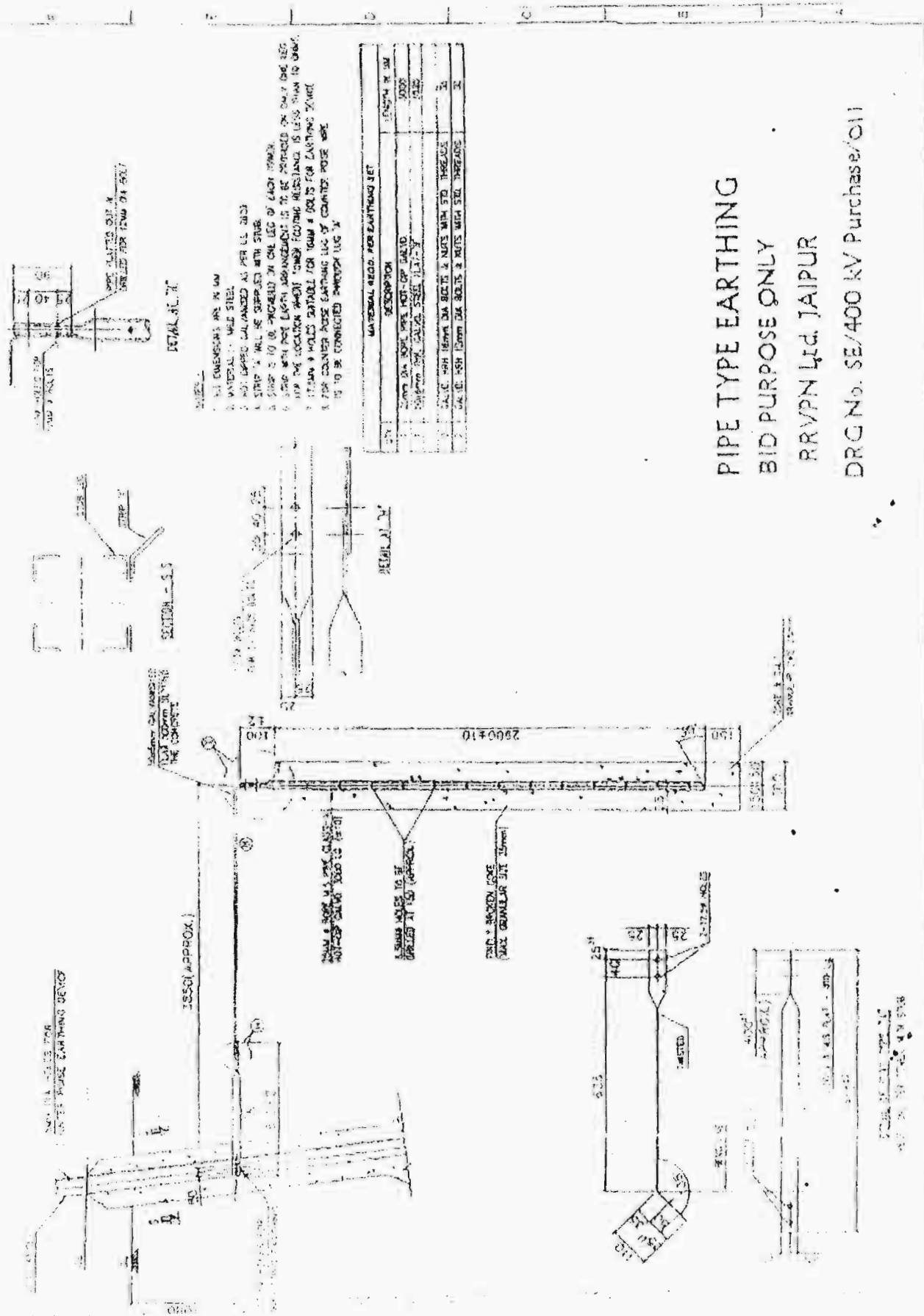
6 Nos./Tower

- NOTES:-
1. ALL DIMENSIONS ARE IN MM.
 2. TO BE GALV. AFTER MANUFACTURE
 3. MATERIAL MILD STEEL AS PER I.S.226

BIRD GUARD
FOR BID PURPOSE ONLY

RRVN LTD., JAIPUR

DRG. No. SE/400 KV Purchase/010



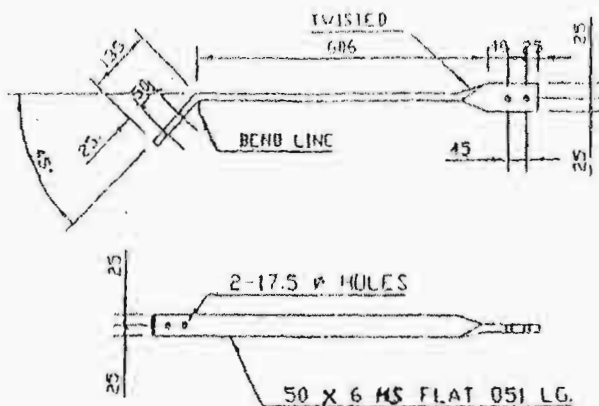
PIPE TYPE EARTHING

BID PURPOSE ONLY

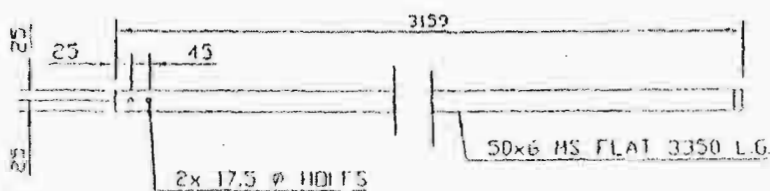
RRVPM Ltd. JAIPUR

DRG No. SE/400 kV Purchase/011





DETAIL OF FLAT TYPE 'C'



DETAIL OF FLAT TYPE 'D'

NOTES

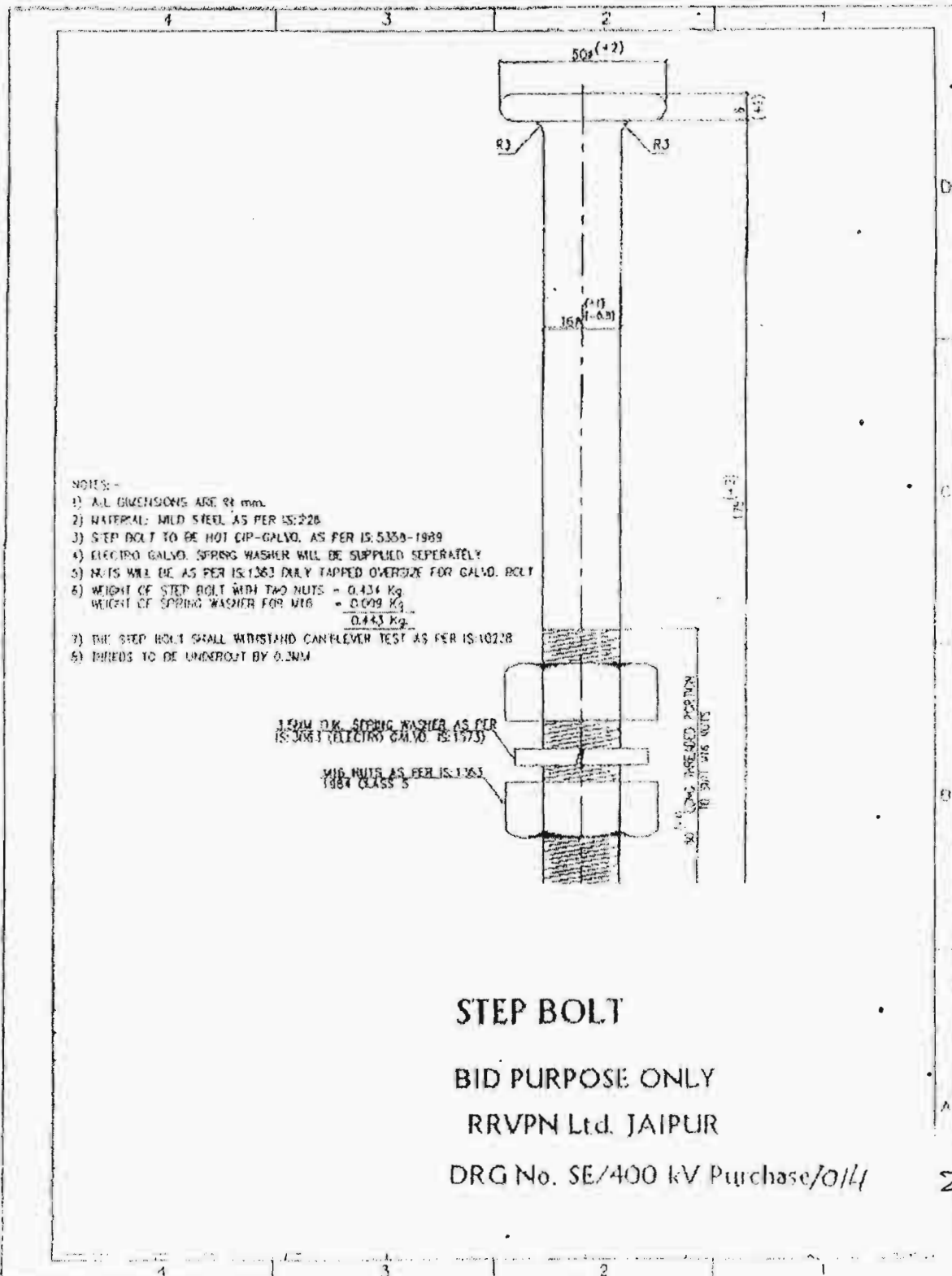
1. ALL DIM. ARE IN MM
2. AFTER FABRICATION, BOTH FLATES ARE TO BE HOT DIP GALVANISED AS PER IS - 2629.
3. 'FLAT TYPE 'C' IS TO BE PROVIDED ON ONE LEG OF EACH TOWER
4. 'FLAT TYPE 'D' IS TO BE PROVIDED WITH PIPE EARTH ARRANGEMENT AND TO BE CONNECTED WITH FLAT 'C' FOR THE LOCATION WHERE TOWER FOOTING RESISTANCE IS MORE THAN 10 OHMS

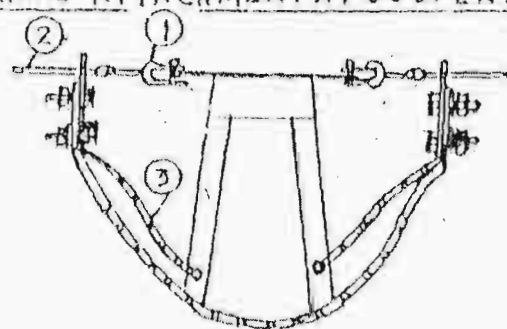
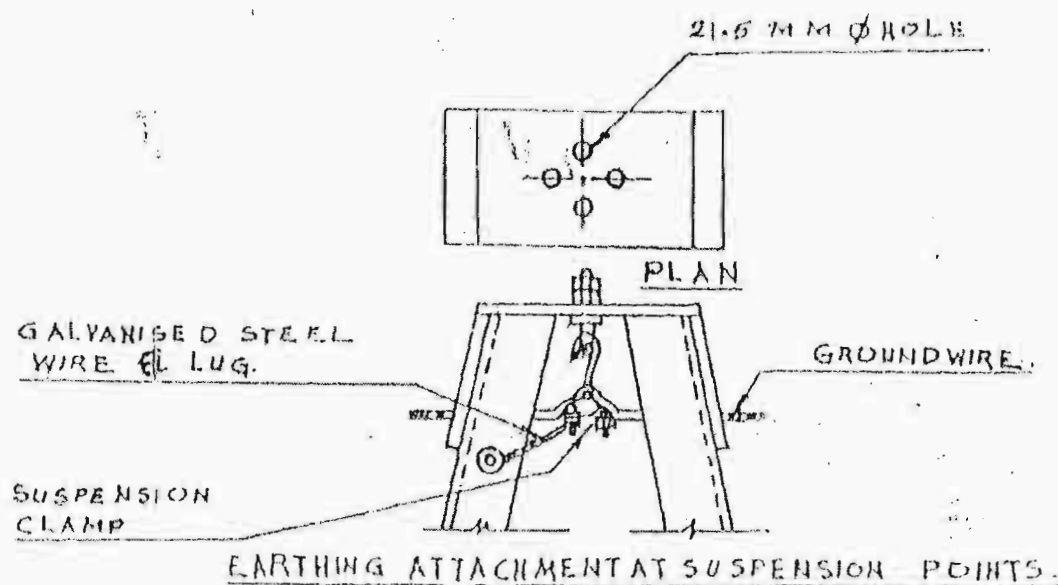
2x13.5 phi HOLES

FOR BID PURPOSE ONLY

LIST OF BOLTS & NUTS WITH SP. WASHER			
S.NO.	SIZE	QTY.	REMARKS
1	M 16Ø x 45 LG.	2	PER TOWER
2	M 12Ø x 35 LG.	2	PER PIPE TYPE EARTHING
3	M 12Ø x 30 LG.	2	PER PIPE TYPE EARTHING

RRVPNLTD. JAIPUR	
PROJECT	400KV TRANSMISSION SYSTEM
TITLE	DETAILS FOR FLATS FOR EARTHING
DWG. NO.	SE/400KV Purchase/03
REV.	





NOTES:—

1. ① SHACKLE.
2. ② COMPRESSION CLAMP
3. ③ FLEXIBLE STEEL WIRE ROPE OF 9.45 MM DIA.

FOR BID PURPOSE
ONLY

RRVPLTD. JAIPUR

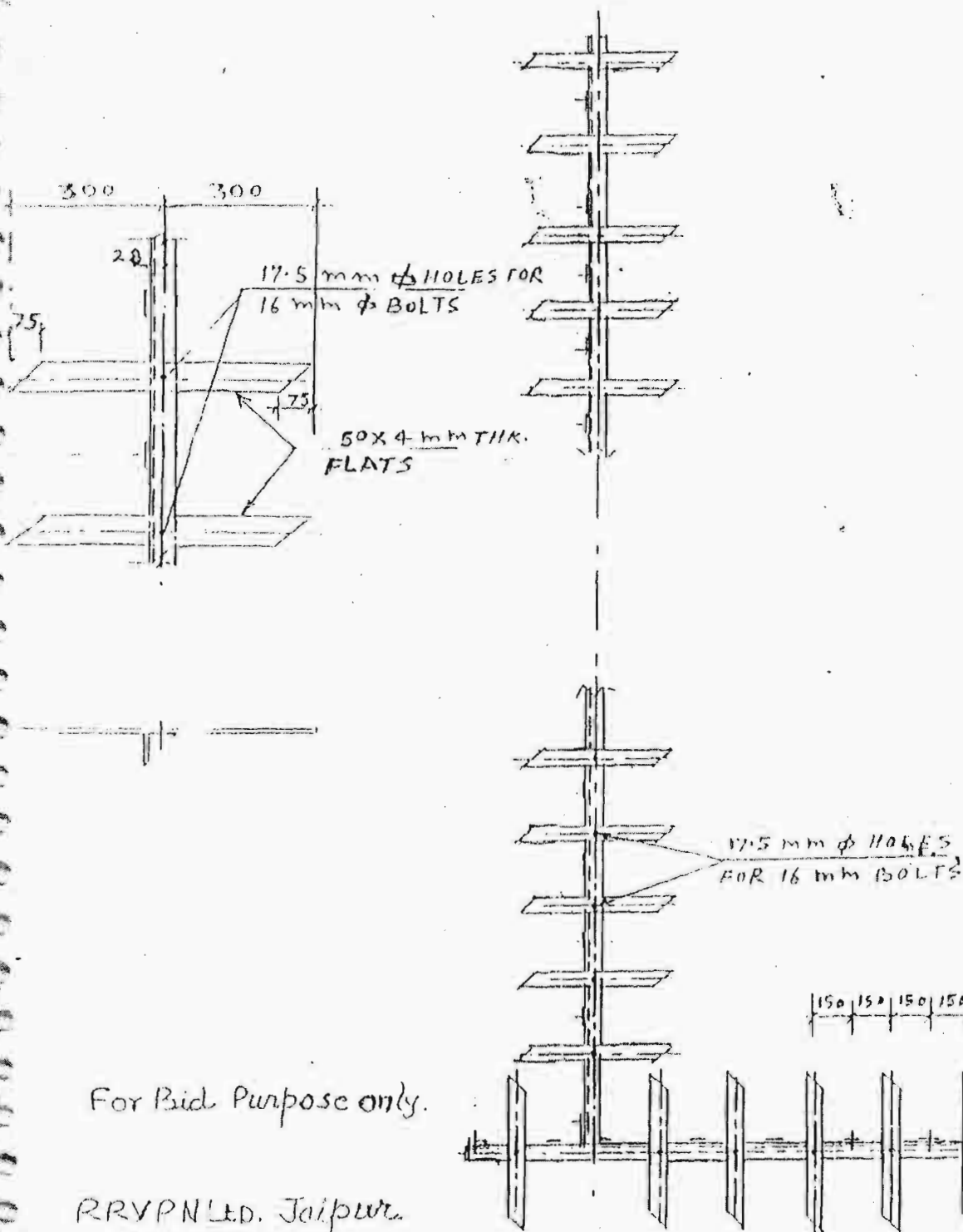
TITLE:-

EARTHING

ATTACHMENT

DRG. No.

SE/400KV Purchase/015

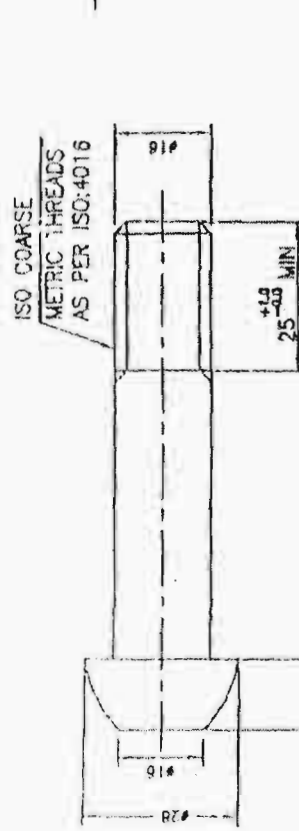
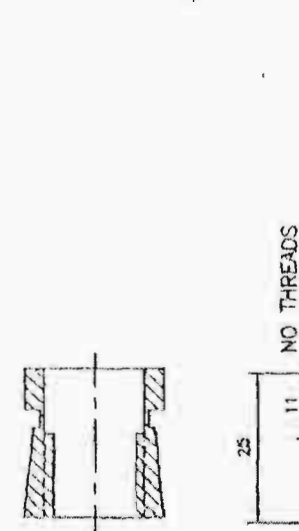
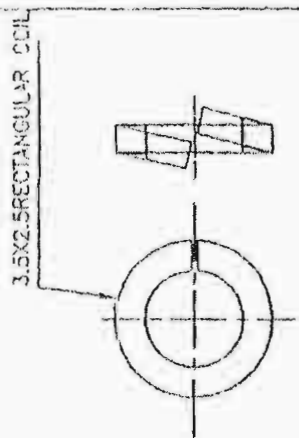


For Bid Purpose only.

RRVPLTD. Jaipur.

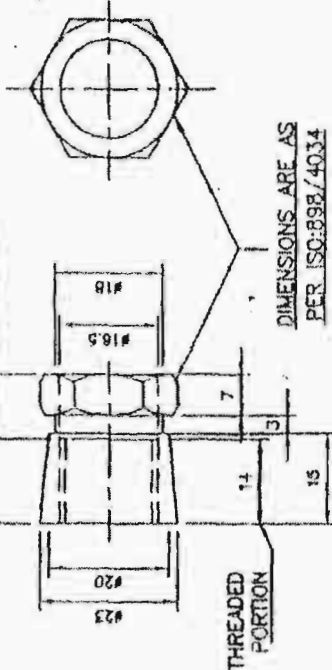
ANTI CLIMBING DEVICE

Dwg. No. SE/400kV Purchases/016

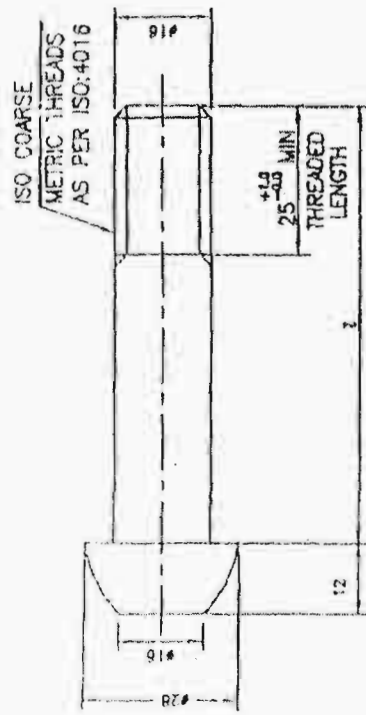


DETAIL OF SPRING WASHER
(AS PER IS:3063)
(NOMINAL DIA - 16mm)

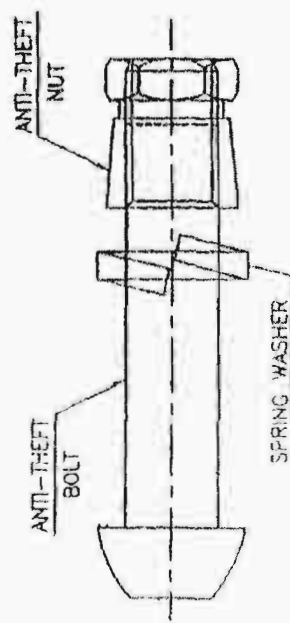
16 DIA BOLT (1)	WT/PCE in Kg. (BOLT WITH NUT)
35mm LONG	0.128
40mm LONG	0.138
45mm LONG	0.144
50mm LONG	0.152
55mm LONG	0.160
60mm LONG	0.168
65mm LONG	0.175
70mm LONG	0.183
75mm LONG	0.191
80mm LONG	0.199
85mm LONG	0.207
90mm LONG	0.215



DETAIL OF ANTI-THEFT NUT



DETAIL OF ANTI-THEFT BOLT



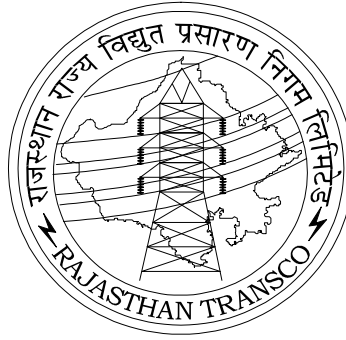
ANTI-THEFT BOLT, NUT & SPRING WASHER

- NOTES:-
1. ALL DIMENSIONS ARE IN MM.
 2. MATERIAL CONFORMING TO PROPERTY CLASS FOR BOLT-5.8 & NUT-5.
 3. BOLT-NUT TO BE HOT DIP GALVANIZED AFTER MANUFACTURE AS PER IS-1367.
 4. NUT TO BE TAPPED OVER SIZE FOR GALVANIZED BOLT.
 5. SPRING WASHER TO BE SUPPLIED WITH EACH BOLT SHALL CONFORM TO IS:3063-1984 (TYPE B).
 6. SPRING WASHER TO BE ELECTROPLATED TO IS:1573-1986 SERVICE CONDITION 4.
 7. BREAKING TORQUE: MINIMUM TORQUE = 10.00kgm MAXIMUM TORQUE = 16.00kgm
 8. ANTI-THEFT BOLT TO BE ACCEPTED FOR REDUNDANT MEMBER CONNECTIONS UPTO TWO BOTTOM MOST PANELS.
 9. AFTER BREAKING OF NUT, LONG RICH PRIMER AND PAINT SHOULD BE APPLIED AS PER PROCESS FOLLOWED IN CASE OF FAC. WELDING.

STANDARD DRAWING

ANTI-THEFT FASTENERS.
BID. PURPOSE ONLY
R R V P N. LTD. JAIPUR

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LIMITED



TECHNICAL SPECIFICATION

FOR

SUPPLY OF ACSR MOOSE CONDUCTOR

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LIMITED

TECHNICAL SPECIFICATION

INDEX

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TECHNICAL SPECIFICATIONS

1.0 TECHNICAL DESCRIPTION OF ACSR MOOSE CONDUCTOR:

1.1 Details of Conductor

1.1.1 The ACSR Moose Conductor shall generally conform to IEC: 1089/ IS:398 except where otherwise specified herein.

1.1.2 The salient parameters of the ACSR Conductor are indicated below.

S.No	PARTICULARS				REQUIREMENT
a.	Stranding and wire diameter for: -				
i)	Aluminium				54/3.53 mm
ii)	Steel				7/3.53mm
b.	Layer	Number of Wires in Strand	Lay Ratio		Direction
			Min.	Max.	
	Central Steel Wire	1	-	-	-
	1 st Steel Layer	6	16	18	LH
	1 st Aluminium Layer	12	12	14	RH
	2 nd Aluminium Layer	18	11	13	LH
	3 rd Aluminium Layer	24	10	12	RH
c.	Nominal Aluminium area (mm ²)				520
d.	Sectional area of aluminium (mm ²)				528.5
e.	Total Sectional area (mm ²)				597
f.	Overall diameter (Approximate) (mm)				31.77
g.	Approximate weight (kg/ kM) excluding mass of grease				2004
h.	Calculated max. D.C. resistance at 20 Deg.C (Ohm/ kM)				0.05552
i.	Minimum breaking load (approx.) (kN)				161.20
j.	Final Modulus of Elasticity (GN/m ²)				69
k.	Coefficient of linear expansion per Deg.C.				19.3x10 ⁻⁶

1.1.3 Standard Technical Particulars

1.1.3.1 The Standard Technical Particulars (STP) of the ACSR conductor are enclosed at Annexure-B of this section. The values indicated in the STP are the minimum and/or maximum values required to be met by the Supplier.

1.2 Workmanship

1.2.1 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

1.2.2 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

1.2.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating as indicated in the STP. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in standard Preece test as indicated in STP. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.

1.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

1.2.5 The area where conductor is to be manufactured shall be covered completely with rubber matting/coir mat/wooden floor.

- 1.2.6 All guides, rollers, pulleys etc. used for manufacturing conductor shall be of Nylon/Hylem or Teflon or other soft materials instead of steel.

1.3 Joints in Wires

1.3.1 Aluminium Wires

- 1.3.1.1 During stranding, no aluminium wire welds shall be made for the purpose of achieving the required conductor length.
- 1.3.1.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However joints are permitted in the inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.
- 1.3.1.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

1.3.2 Steel Wires

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

1.4 Tolerances

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual aluminium and steel strands and lay-ratio of the conductor

1.5 Materials

1.5.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%. They shall have the same properties and characteristics as prescribed in IEC: 889.

1.5.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 888.

1.5.3 Zinc

The zinc used for galvanizing shall be electrolytic High Grade Zinc of 99.95% purity as per IS209. It shall conform to and satisfy all the requirements of IS: 209.

1.6 Standard Length

- 1.6.1 The standard length of the conductor shall be as indicated in the STP. All lengths outside this limit of tolerance shall be treated as random lengths.
- 1.6.2 The Employer reserves the right to place orders for the lengths above the standard length on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.
- 1.6.3 The total ordered quantity can be supplied with the tolerance of plus/minus standard length of one drum.

1.7 Deferment

- 1.7.1 Supplies due for delivery by a supplier against any purchase order can be deferred with the approval of Whole-time Directors in unforeseen or unavoidable circumstances or force majeure conditions. For deferment of supply a seven days notice shall be served upon the supplier by the purchase officer. One-month notice shall also be served for lifting

the deferment intimating the date of deferment being lifted. Extension in delivery period equal to the period of deferment shall be allowed.

2.0 TESTS AND STANDARDS:

2.1.1 Type Tests

The bidder shall submit original/attested photo copies of the following latest type test certificates as given below, not older than seven years as on the date of bid opening, from a Government approved/ a Government recognised/ a NABL/ ILAC Accredited Laboratory, as per this Vol. II, Technical Specification or equivalent International standards like IEC, IEEE etc., which should be valid upto expiry of validity of offer. However, the type test report for higher class & rating can be accepted for scrutiny of technical bid. Bids without type test reports will not be considered for evaluation.

(a)	UTS test on stranded conductor	Annexure-A
(b)	Corona extinction voltage test (dry)	
(c)	Radio interference voltage test (dry)	
(d)	DC resistance test on Stranded conductor	

2.1.2 Acceptance Tests

Acceptance Tests on ACSR 'MOOSE' Conductor (one sample for every 10 drums or part thereof offered for inspection).

(a)	Visual and dimensional check on drum	Annexure-A
(b)	Visual check for joints scratches etc. and length measurement of conductor by rewinding	
(c)	Dimensional check on steel and Aluminium strands	
(d)	Check for lay-ratios of various layers	
(e)	Galvanising test on steel strands	
(f)	Torsion and Elongation tests on steel strands	
(g)	Breaking load test on steel and Aluminium strands	
(h)	Wrap test on steel and Aluminium strands	IEC: 888 & 889
(i)	DC resistance test on Aluminium strands	IEC: 889
(j)	Procedure qualification test on welded joint of Aluminium strands	Annexure-A
(k)	Barrel Batten Strength test	

Note : All the above tests except (j) shall be carried out on Aluminium and steel strands after stranding only.

2.1.3 Routine Test

Routine tests to be conducted on ACSR 'MOOSE' conductor:-

(a)	Check to ensure that the joints are as per specification	Record of joints for all the drums shall be reviewed at the time of final inspection.
(b)	Check that there are no cuts, fins etc., on the strands.	On each drum
(c)	Check that drums are as per specification	On each drum
(d)	All acceptance tests as mentioned above to be carried out on each coil	Review of record at the time of final inspection.

2.1.4 TESTS DURING MANUFACTURE:

Following tests during manufacture on ACSR 'MOOSE' Conductor

(a)	Chemical analysis of zinc used for galvanising	Annexure-A
(b)	Chemical analysis of Aluminium used for making Aluminium strands	
(c)	Chemical analysis of steel used for making steel strands	

2.1.5 INSPECTION AT SITE:

- (a) Surface condition (visual check 100%)
- (b) Length measurement by weight of drums (20% of drums received)

3.0 Testing Expenses

- 3.1 The entire cost of testing for the type tests, acceptance and routine tests and Tests during manufacture specified herein shall be treated as included in the quoted unit price.

3.2 Additional Tests

- 3.2.1 The Employer reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.
- 3.2.2 The Employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of Supplier to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Employer.

3.3 Test Reports

- 3.3.1 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Employer's representative.
- 3.3.2 Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

4.0 Inspection

- 4.1 The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the Supplier's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.
- 4.2 The Supplier shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.
- 4.3 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the latter case also the conductor shall be dispatched only after satisfactory testing for all tests specified herein have been completed.
- 4.4 The acceptance of any quantity of material shall in no way relieve the Supplier of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

5.0 Test Facilities

- 5.1 The following additional test facilities shall be available at the Supplier's works:
- a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer digital, ohm metre etc.
 - b) Standard resistance for calibration of resistance bridges.
 - c) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc. with traverse laying facilities.

6.0 Packing

- 6.1 The conductor shall be supplied in non-returnable, strong, wooden drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall be responsible for any loss or damage during

transportation handling and storage due to improper packing. The drums shall generally conform to IS:1778, except as otherwise specified hereinafter.

- 6.2 The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.
- 6.3 The general outline of the drum for conductor shall be as in the annexed drawings. The Bidder should submit their proposed drum drawings along with the bid.
- 6.4 For conductor, one standard length shall be wound on each drum.
- 6.5 All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.
- 6.6 The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75mm. Where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.
- 6.7 The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.
- 6.8 Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.
- 6.9 Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.
- 6.10 The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.
- 6.11 Before reeling, card board or double corrugated or thick bituminised water-proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the conductor, the exposed surface of the outer layer of conductor shall be wrapped with water proof thick bituminised bamboo paper to preserve the conductor from dirt, grit and damage during transport and handling.
- 6.12 A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.
- 6.13 Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.
- 6.14 The nuts on the barrel studs shall be tack welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.
- 6.15 A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steal drum and secured to the central steel plate by welding.
- 6.16 Outside the protective lagging, there shall be minimum of two binder consisting of hoop iron/galvanised steel wire. Each protective lagging shall have two recesses to accommodate the binders.
- 6.17 The conductor ends shall be properly sealed with heat shrinkable sleeves and shall be properly secured with the drum with the help of “U” clamps after covering the conductor below clamp with PVC adhesive tape to avoid loosening of conductor layers during transit and handling.
- 6.18 As an alternative to wooden drum Bidder may also supply the conductors in non-returnable painted steel drums. After preparation of steel surface according to IS:9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the Bidder should quote in the package.

7.0 Marking

Each drum shall have the following information stenciled on it in indelible ink along with other essential data :

- (a) Contract/Award letter number.
- (b) Name and address of consignee.
- (c) Manufacturer's name and address.
- (d) Drum number
- (e) Size of conductor
- (f) Length of conductor in meters
- (g) Arrow marking for unwinding
- (h) Position of the conductor ends
- (i) Distance between outer-most Layer of conductor and the inner surface of lagging.
- (j) Barrel diameter at three locations & an arrow marking at the location of the measurement.
- (k) Number of turns in the outer most layer.
- (l) Gross weight of drum after putting lagging.
- (m) Tear weight of the drum without lagging.
- (n) Net weight of the conductor in the drum.
- (o) CIP/MICC No.

The above should be indicated in the packing list also.

8.0 Verification of Conductor Length

- 8.1 The supplier/manufacturer shall provide all facilities at their works for inspection of atleast 10% (ten percent) of conductor drums (minimum one drum) selected at random by the authorised representative of the Employer for checking/ verification of conductor length/manufacturing defects by transferring the conductor from one drum to another empty drum and at the same time measuring the length of the conductor so transferred by means of a meter.
- 8.2 In case the length is found short in any of the drum selected on rewinding then the Employer shall be at liberty to check the entire drums offered for inspection in that particular lot.

9.0 Standards

- 9.1 The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendment changes adopted and published, unless specifically stated otherwise in the Specification.
- 9.2 In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

S. No.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS: 398 Part-I -1996	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC:1089-1991 BS:215-1970
3.	IS:398 Part-II -1996	Aluminum Conductor Galvanised Steel Reinforced	BS:215-1970 IEC:1089-1991
4.	IS:398 Part-V -1992	Aluminum Conductor Galvanised Steel- Reinforced For Extra High Voltage (400 KV) and above	IEC:1089-1991 BS:215-1970
5.	IS : 1778-1980	Reels and Drums for Bare Conductors	BS:1559-1949
6.	IS : 1521-1991	Method of Tensile Testing of Steel Wire	ISO 6892-1984
7.	IS : 2629-1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
8.	IS : 2633-1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	
9.	IS : 4826-1992	Galvanised Coating on Round Steel Wires	IEC : 888-1987 BS:443-1969
10.	IS : 6745-1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433-1969 ISO 1460 - 1973
11.	IS : 8263-1990	Method of Radio Interference Tests on High Voltage Insulators	IEC:437-1973 NEMA:107-1964 CISPR

12.		Zinc Coated steel wires for stranded Conductors	IEC : 888-1987
13.		Hard drawn Aluminium wire for overhead line conductors	IEC : 889-1987

1. Tests on Conductor

1.1 UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed on a tensile testing machine. The load shall be increased at a steady rate upto 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to 100% of the UTS of conductor and held for one minute. The Conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and this value shall be recorded.

1.2 Corona Extinction Voltage Test

The sample assembly with each conductor of 5 m length shall be strung as per the configuration shown in the Table below.

<i>Line Configuration</i>	<i>No of conductor samples per Bundle</i>	<i>Spacing (mm)</i>	<i>Maximum Height of the conductor above ground (m)</i>
400kV with Quad ACSR MOOSE	Four	457	8.84

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than that indicated in the STP. There shall be no evidence of corona on any part of the samples. The test should be conducted without corona control rings. However, small corona control rings may be used to prevent corona in the end fittings. The voltage should be corrected for standard atmospheric conditions.

1.3 Radio Interference Voltage Test

Under the conditions as specified under (1.2) above, the conductor samples shall have radio interference voltage as indicated in the standard technical particulars enclosed at Annexure-B of this section. This test may carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-437

1.4 D.C. Resistance Test on Stranded Conductor

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or digital ohm-metre of sufficient accuracy by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20°C as per IS:398. The resistance corrected at 20°C shall conform to the requirements indicated in the STP.

1.4 Chemical Analysis of Aluminium and Steel

Samples taken from the Aluminium and steel ingotoils/strands shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this Specification.

1.5 Visual and Dimensional Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this Specification.

1.6 Visual Check for Joints, Scratches etc.

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this Specification. Ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative.

1.7 Dimensional Check on Steel and Aluminium Strands

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification.

1.8 Check for Lay-ratios of Various Layers

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this Specification.

1.9 Procedure Qualification test on welded Aluminium strands

Two Aluminium wire shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the breaking strength of individual strands.

1.10 Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

1.11 Galvanizing Test

The test procedure shall be as specified in IEC : 888. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.12 Torsion and Elongation Tests on Steel Strands

The test procedures shall be as per clause No. 10.3 of IEC : 888. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the STP. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 250 mm.

1.13 Check on Barrel Batten strength of Drums

The details regarding barrel batten strength test will be discussed and mutually agreed to by the Supplier & Employer in the Quality Assurance Programme.

STANDARD TECHNICAL PARTICULARS OF ACSR MOOSE CONDUCTOR

Sl. No.	Description	Unit	Guaranteed Values	
1.0	Raw Materials			
1.1	Aluminium			
a)	Minimum purity of Aluminium	%	99.50	
b)	Maximum copper content	%	0.04	
1.2	Steel wires/ rods			
a)	Carbon	%	0.50 to 0.85	
b)	Manganese	%	0.50 to 1.10	
c)	Phosphorous	%	Not more than 0.035	
d)	Sulphur	%	Not more than 0.045	
e)	Silicon	%	0.10 to 0.35 (Max.)	
1.3	Zinc			
a)	Minimum purity of Zinc	%.%	99.95	
2.0	Aluminium strands after stranding			
2.1	Diameter			
a)	Nominal	mm	3.53	
b)	Maximum	mm	3.55	
c)	Minimum	mm	3.51	
2.2	Minimum breaking load of strand			
a)	Before stranding	KN	1.57	
b)	After stranding	KN	1.49	
2.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.002921	
3.0	Steel strand after stranding			
3.1	Diameter			
a)	Nominal	mm	3.53	
b)	Maximum	mm	3.59	
c)	Minimum	mm	3.47	
3.2	Minimum breaking load of strand			
a)	Before stranding	KN	12.63	
b)	After stranding	KN	11.99	
3.3	Galvanising			
a)	Minimum weight of zinc coating per sq.m.	gm	260	
b)	Minimum number of dips that the galvanised strand can withstand in the standard preece test	Nos.	3 dips of one min. each.	
c)	Min. No. of twists in gauge length equal 100 times the dia. of wire which the strand can withstand in the torsion test (after stranding)	Nos	16	
4.0	Stranded Conductor			
4.1	UTS of the conductor	kN	161.20 (Min.)	
4.2	Lay length of outer steel layer	mm	Max	Min
a)	Outer Steel layer	mm	18	16
b)	12 wire Aluminium layer	mm	14	12
c)	18 wire Aluminium layer	mm	13	11
d)	24 wire Aluminium Layer	mm	12	10
4.3	DC resistance of the conductor at 20°C	ohm/km	0.05552	
4.4	Minimum corona Extinction Voltage (line to phase) under Dry condition	kV (rms)	320	
4.5	RIV at 1 Mhz at 305 Amp (line to phase) under Dry condition	Micro-Volts	Below 1000	
4.6	Standard length of the conductor	m	1800	
4.7	Tolerance on Standard length	%	(+/-) 5	
4.8	Direction of lay of outer layer		Right Hand	
4.9	Linear mass of the conductor			
a)	Standard	kg/km	2004	
b)	Minimum	kg/km	1969	
c)	Maximum	kg/km	2040	

Ceiling weights of towers and their body extensions
A. For 400kV D/C line

Sr No.	Description	Unit	Ceilling Weight			
			Tower		Stub	
			HT	MS	HT	MS
i	Weight of towers and their body extension including D-Shackles, U-Bolt, Hangers, Bird Gaurds, Pack Washers , etc.					
i	TTDA	MT	4.014	5.488	0.311	0.000
ii	TTDB	MT	8.526	7.849	0.565	0.002
iii	TTDC	MT	10.280	7.768	0.709	0.002
iv	TTDD	MT	11.648	10.424	0.950	0.002
vi	+3M Ext. TTDA	MT	0.263	1.218		
vii	+3M Ext. TTDB	MT	0.660	2.466		
viii	+3M Ext. TTDC	MT	0.810	2.549		
ix	+3M Ext. TTDD	MT	0.759	4.100		
x	+6M Ext. TTDA	MT	0.536	1.605		
xi	+6M Ext. TTDB	MT	1.090	3.570		
xii	+6M Ext. TTDC	MT	1.291	3.805		
xiii	+6M Ext. TTDD	MT	1.386	4.861		
xiv	+9M Ext. TTDA	MT	0.981	1.971		
xv	+9M Ext. TTDB	MT	1.567	4.574		
xvi	+9M Ext. TTDC	MT	1.872	4.778		
xvii	+9M Ext. TTDD	MT	2.113	6.262		
xviii	+18M Ext. TTDD	MT	4.618	16.842	0.762	
xix	+25M Ext. TTDD	MT	6.548	30.062	0.762	

B. Ceiling weights of nuts & bolts etc for towers, stubs and their body extensions for 400kV Line :-

S. No.	Description of item	Unit	Ceiling Unit Weight of Bolts & Nuts etc. for (in MT)		
			Tower	Stub	Total
1	2	3	5	6	7
2	Bolts, Nuts, anti theft fastners, step bolts & nuts & washers etc. for tower & their extensions, stubs.				
i	TTDA	MT	0.523	0.011	0.534
ii	TTDB	MT	0.654	0.012	0.666
iii	TTDC	MT	0.680	0.014	0.694
iv	TTDD	MT	0.790	0.016	0.806
v	Special tower	MT			0.000
vi	+3M Ext. TTDA	MT	0.075		0.075
vii	+3M Ext. TTDB	MT	0.117		0.117
viii	+3M Ext. TTDC	MT	0.090		0.090
ix	+3M Ext. TTDD	MT	0.165		0.165
x	+6M Ext. TTDA	MT	0.087		0.087
xi	+6M Ext. TTDB	MT	0.132		0.132
xii	+6M Ext. TTDC	MT	0.127		0.127
xiii	+6M Ext. TTDD	MT	0.187		0.187
xiv	+9M Ext. TTDA	MT	0.139		0.139
xv	+9M Ext. TTDB	MT	0.179		0.179
xvi	+9M Ext. TTDC	MT	0.182		0.182
xvii	+9M Ext. TTDD	MT	0.260		0.260
xviii	+18M Ext. TTDD	MT	0.654	0.02	0.669
xix	+25M Ext. TTDD	MT	1.074	0.02	1.089
	TOTAL				

C. Ceiling weights and volumes of foundations for 400kV Line:

Tower type	Foundation for soil type	CEILING WEIGHT & VOLUMES OF FOUNDATIONS			
		M20	M10	Excavation	Steel
		Cum	Cum	Cum	Kg
DA+0	Normal Dry	6.37	1.20	65.07	398.00
	Wet/Sandy	11.13	2.37	120.90	704.00
	SFR/DFR	9.52	1.98	62.66	602.00
DA+3/6/9	Normal Dry	6.37	1.20	65.07	398.00
	Wet/Sandy	11.13	2.37	120.90	704.00
	SFR/DFR	9.52	1.98	62.66	602.00
DB+0	Normal Dry	12.98	2.24	126.70	1250.00
	Wet/Sandy	20.64	4.22	229.64	2190.00
	SFR/DFR	17.12	3.13	76.56	1389.00
DB+3/6/9	Normal Dry	12.98	2.24	126.70	1250.00
	Wet/Sandy	20.64	4.22	229.64	2190.00
	SFR/DFR	17.12	3.13	76.56	1389.00
DC+0	Normal Dry	16.19	2.85	157.66	1587.00
	Wet/Sandy	25.40	5.42	289.84	3169.00
	SFR/DFR	22.10	4.04	81.46	1756.00
DC+3/6/9	Normal Dry	16.19	2.85	157.66	1587.00
	Wet/Sandy	25.40	5.42	289.84	3169.00
	SFR/DFR	22.10	4.04	81.46	1756.00
DD+0	Normal Dry	26.65	4.06	218.60	1958.00
	Wet/Sandy	42.22	7.26	381.48	3572.00
	SFR/DFR	32.42	5.50	91.54	2434.00
DD+3/6/9	Normal Dry	26.65	4.06	218.60	1958.00
	Wet/Sandy	42.22	7.26	381.48	3572.00
	SFR/DFR	32.42	5.50	91.54	2434.00

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LIMITED

TECHNICAL SPECIFICATION

FOR

TURNKEY PROJECT (DEPOSIT WORK)

FOR

CONSTRUCTION OF

- (i) LILO OF ALREADY CONSTRUCTED 220KV S/C BALOTARA – HRRL LINE AT PROPOSED 400 KV GSS PACHPADARA – 3 KMS.
- (ii) 2X220 KV S/C LINE [ON D/C TOWERS] FROM PROPOSED 400KV GSS PACHPADARA TO M/S HRRL – 28 KMS.
- (iii) LILO OF 220KV S/C BALOTARA – BORANDA LINE AT 400KV GSS HRRL (RVPN LAND) – 10 KMS.

UNDER SPECIFICATION

RVPN/SE(Cont-II)/XEN-3/BN- 9019002102

VOLUME –II

SECTION - I

GENERAL TECHNICAL REQUIREMENTS

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GENERAL TECHNICAL REQUIREMENTS

1. General Information and Scope

1.1 Scope

1.1.1 The following 220kV transmission line is included in the scope of the Contractor:-

S. No.	NAME OF CONSTRUCTION OF 220kV) TRANSMISSION LINES	LINE LENGTH (In KM)
1.	LILO OF ALREADY CONSTRUCTED 220KV S/C BALOTARA – HRRL LINE AT PROPOSED 400 KV GSS PACHPADARA – 3 KMS.	3 Kms.
2.	2X220 KV S/C LINE [ON D/C TOWERS] FROM PROPOSED 400KV GSS PACHPADARA TO M/S HRRL – 28 KMS.	28 Kms.
3.	LILO OF 220KV S/C BALOTARA – BORANDA LINE AT 400KV GSS HRRL (RVPN LAND) – 10 KMS.	10 Kms.

1.1.2 This Specification covers the following scope of works:

- (i) detailed Survey, including route alignment, profiling, tower optimization & spotting soil resistivity measurement & geotechnical investigation and check survey,
- (ii) Fabrication, Galvanization and delivery of the transmission line supporting structure (towers) for 220kV lines complete in all respect including U-bolts with nuts, hangers with nuts and bolts, D-Shackles, with nuts and bolts, links, bird guards, bird flappers (if required) of appropriate design if identified during the ESAI study (if conducted) or mentioned in Approvals to be received from Forest Department for given line sections as a necessary accessory, anti-climbing devices, flat washers etc. The scope also covers supply of other line material like insulator, hardware, accessories, nuts, bolts, Conductor , OPGW etc. (as per the bidding schedules) and also survey, check survey, foundation, erection, testing and commissioning of 220kV transmission lines.

The scope of bidder also includes manufacturing, engineering, inspection at manufacturer's works for supply of material at site i.e. Disc insulators/Long Rod Insulators, hardware fittings for conductor , ACSR Zebra Conductor and other line accessories etc.

- (iii) type testing, if not carried out earlier, of all line material as per requirement given in related chapters,
- (iv) selection of foundations for different types of towers and casting of foundation for tower footings as per owner's design, design of foundation for extension of tower (if not available with owner) for different type of soil condition,
- (v) erection of towers, tack welding of bolts and nuts including supply and application of zinc rich primer and enamel paint, tower earthing, fixing of insulator strings, stringing of conductor and OPGW fiber optic cable along with all necessary line accessories,
- (vi) testing and commissioning of erected transmission line
- (vii) De-stringing of Conductor/Earth wire/OPGW:
 - (a) Destraining of ACSR Zebra Conductor: Dismantling of vibration dampers and armour rods, removal of conductor from clamps and fitting in rollers, de-

tensioning, de-hoisting of insulator string as required and collecting the material & depositing the same in store and stacking.

- (b) Destraining of Earth wire: Dismantling of earth bonds, vibration dampers, declipping & fitting in rollers, detensioning and collecting the material & depositing the same in our store and stacking.
- (c) Destraining of OPGW: Dismantling of earth bonds, vibration dampers, declipping & fitting in rollers, de-tensioning and collecting the material & depositing the same in our store and stacking.
- (xi) Dismantling of Towers: Dismantling of super structure along with extension, having tack welded Bolt & Nuts, including removing of D shackles, hangers, U-Bolts, step bolts, ACD, Danger Plate, Number Plate, Phase Plate of tower. The tack welded / Anti-theft bolts & nuts which are to be cut are also required to be deposited as scrap by weight. However, wastage of 10% shall be allowed for these items. Transportation of tower members and nuts & bolts to the store and depositing the same in store & stacking member wise.

~~The cost of dismantling of towers shall include the weight of tower members, nuts & bolts and all accessories as per the bill of material of towers. No shortages and wastage shall be allowed except for nuts & bolts which have been tack welded / Anti-theft and are required to be cut. No tower members shall be damaged / bent.~~

- (xii) other items not specified above but required to complete the work.

- 1.1.2.1
- (a) The various items of work are described very briefly in the appropriate Schedule of BPS/BOQ. The various items of the BPS/BOQ shall be read in conjunction with the corresponding sections in the Technical Specifications including amendments and, additions, if any. The Bidder's quoted rates shall be based on the description of activities in the BPS as well as other necessary operations required to complete the works detailed in these Technical Specifications.
 - (b) The Unit rates quoted shall include minor details which are obviously and fairly intended, and which may not have been included in these documents but are essential for the satisfactory completion of the various works.
 - (c) The unit rate quoted shall be inclusive of all plant equipment, men, material skilled and unskilled labour etc. essential for satisfactory completion of various works.
 - (d) All measurements for payment shall be in S.I. units, lengths shall be measured in meters corrected to two decimal places. Areas shall be computed in square meters & volume in cubic meters rounded off to two decimals.

- 1.1.3
- All the raw materials, such as steel, zinc for galvanizing, reinforcement steel, cement, coarse and fine aggregates for tower foundation, coke and salt for tower earthing etc. are included in the Contractor's scope of supply.

1.1.4 Stringing

The contractor shall deploy appropriate tools / equipments / machinery to ensure that the stringing operation is carried out without causing damage to conductor and conductor is installed at the prescribed sag-tension as per the approved stringing charts.

1.2 Details of Transmission Line Routes and Terrain

The detailed survey shall be carried out using GPS, Total stations, digital theodolites etc. along the approved route alignment. As an alternative, the contractor may also use ALTM (Airborne Laser Terrain Modeling) techniques of equal or better accuracy for the detailed survey.

Bidders may visit the line route to acquaint themselves with terrain conditions and associated details of the proposed transmission lines.

1.3 Location Details and Terminal Points

1.3.1 The transmission line shall emanate in the state of Rajasthan.

1.3.2 The Contractor shall have to construct the 220KV transmission line completely up to dead end or terminal towers on either ends of the transmission line or part thereof. Stringing shall also be carried out from dead end tower to gantry/terminal arrangements/terminal points.

1.4 Access to the Line and Right of Way

Right of way and way leave clearance shall be arranged by the owner in accordance with work schedules.

2.0 Qualification Requirement for Contractor's Supplied Line Materials

The Bidder should have assured access to supply Tower material, Disc Insulators, ACSR Zebra Conductor, Hardware fittings and accessories for conductor and OPGW and other line materials from the manufacturers (Vendors) covered in the following list. However, the owner reserves the right to approve alternate vendors subject to meeting the technical specification, previous performances (with State/Central Transmission Utilities), availability of after sales support/service etc. in the overall interest of Nigam/Project.

In case, bidder is manufacturer of the items/equipments required for the project, then the bidder will supply own manufactured items/material. The vendors/manufacturers approved by the Nigam shall be final.

If the bidder proposes to supply material from vendors other than from approved vendors list then they shall furnish qualifying details of such vendors as detailed hereunder. Letter of Authorization/Undertaking from the Manufacturers as per proforma (Schedule-G) shall be submitted by successful bidder before commencement of supply.

S.No.	Equipment/Material	Minimum experience required
1	220KV Transmission Line Tower, Hardware Fittings and Accessories for Conductor, Disc Insulator, ACSR Zebra conductor, Danger/Phase/Number/Circuit plates, Pipe/Counter poise earthing, Galvanized Bolts & Nuts, Washers/Spring Washer/ Forged items (D-shackle, Hanger, U-Bolt), OPGW Cable & its H/W etc.	80% quantity of Equipment/Material covered in the Bid (equivalent or higher rating) should have been manufactured & supplied in any one year during the past five years by the manufacturer of that Equipment/Material covered in the Bid, as on the date of submission of request. Out of which 50% quantity of Equipment/Material covered in the Bid should have been satisfactory performance in any one year during the past five years. To substantiate above requirement the successful bidder shall furnish the following i. Certificate from Chartered Accountant bearing membership number with the name & address of the Chartered Accountant. The certificate should clearly indicate the quantity supplied, period of supply, name and address of the purchaser and end user. ii. Duly self-attested performance certificates from the purchaser/ end user clearly indicating the quantity supplied, date of commissioning, rating and voltage class.

3.0 List of Approved Vendors

S. No.	NAME OF ITEM	NAME OF VENDORS
1.	Hardware Fittings and Accessories for Conductor and Earthwire	(i) M/s EMI Transmission Ltd., Mumbai (ii) M/s International Transmission Products Pvt. Ltd., Mumbai. (iii) M/s. EMC Steelal Limited, Kolkatta (iv) M/s Asbesco India Pvt. Ltd., Kolkatta (v) M/s Rajasthan Transmat Pvt. Ltd., Jaipur (vi) M/s Burma Electro corporation, Jalandhar city (vii) M/s Tyco Electronics (I) Pvt. Ltd., Bangalore (viii) M/s. IAC Electricals Pvt. Ltd., Kolkatta (ix) M/s. TAG Corporation, Chennai (x) M/s. Rashtraudyog Ltd., Kolkata (xi) M/s. Modern Malleables Ltd., Kolkata (xii) M/s Krsna Transmission Hardware Mfg. Pvt. Ltd., Vadodara (Gujrat) (xiii) M/s Premier Power Products (Calcutta) Pvt. Ltd., Kolkata (xiv) M/s Aumni Transmission Industries P. Ltd., Vadodara (xv) M/s S.R Electrical P. Ltd. Howrah (xvi) M/s Shyam Engineering Vadodara (xvii) M/s Mosderfer Pvt. Ltd. Mumbai (xviii) M/s Asbesco Kolkata. (xix) M/s Excel Associates Pvt. Ltd. Jaipur (xx) M/s Electromech&Transtech Pvt. Ltd. Kolkata (xxi) M/s Aluminum Electricals Industries Pvt. Ltd. Banaras
2	Insulators: a) Porcelain Long Rod b) Disc c) Composite polymer Long Rod	(i) M/s. Modern Insulators, Abu Road (i) M/s. BHEL Amethi (UP) (ii) M/s. WSI, Chennai (iii) M/s. Aditya Birla Insulators, Hoogly (WB) (iv) M/s. Suraj Ceramics, Bikaner (v) M/s. Imperial Ceramics Industries, Bikaner, (vi) M/s. Shreeji Power & Insulators P. Ltd. Gujrat (vii) M/s. Bikaner Ceramics Pvt. Ltd., Bikaner (i) M/s Deccan Enterprises Ltd. Hyderabad (ii) M/s Goldstone Infratech Ltd, Secunderabad
3.	Danger plate/Phase plate/Number plate/Circuit plate	(i) M/s Hind Enamel Works, Mumbai (ii) M/s J.K. Ceramicss, Pune (iii) M/s Lohar Engineers, Jaipur/Mumbai (iv) M/s. Premier Enamle, Aligarh (v) M/s. Kaveri Enamles and Allied Ltd., Bangalore (vi) M/S. Transan&Co., Howrah (vii) M/s Aisha Transmission Products, Jaipur. (viii) M/s Vinayak Industries Ltd. Jaipur
4.	Pipe type and Counter Poise earthing	(i) M/s Reliance Engineering Co., Thane (ii) M/s Bharat Wire Ropes Ltd., Mumbai (iii) M/s Lohar Engineers, Jaipur/Mumbai (iv) M/s Surav Industries Jaipur

		(v) M/s Premier Power Products (Calcutta) Pvt. Ltd., Kolkata (vi) M/s. Aisha Transmission, Jaipur (vii) M/s Z.M. Engg. works, Mumbai (viii) M/s Modern Engineering Works, Mumbai (ix) M/s General Forging Works, Mumbai (x) M/s. Trans Accessories Forging Co., Mumbai (xi) M/s. Essar Forgings, Boiser (xii) M/s. Supreme & Co. Pvt. Ltd., Kolkata (xiii) M/s. Larsen & Toubro, Pithampur/Pondicheri (xiv) M/s. Madras Hard Tools Ltd., Chennai (xv) M/s. Saurav Industries, Jaipur (xvi) M/s. Perfect Engineering Works Jaipur (xvii) M/s. R.G. Enterprises, Jaipur (xviii) M/s. Brahampuri Steels Limited, Jaipur. (xix) M/s Reliance Fabricators, Jaipur (xx) M/s Man Structurals Pvt. Ltd., Jaipur (xxi) M/s. Aisha Transmission Products, Jaipur
5.	Galvanized Bolts & Nuts and Galvanized Step Bolt 16x175	(i) M/s. Nexo Industries Pvt. Ltd., Ludhiana (ii) M/s. A.V. Forgings, Mohali (iii) M/s. Ravi Engineers, Amritsar (iv) M/s. Karamtara Fasteners, Mumbai. (v) M/s. Deepak Fasteners, Ludhiana. (vi) M/s. Forex Fasteners, Ludhiana. (vii) M/s. Garg Fasteners, Ludhiana (viii) M/s Techman India, Chandigarh (ix) M/s A.S.P. Pvt.Ltd.,Howrah (x) M/s Millenium structures (India)Ltd., Indore (xi) M/s Sterling olts(P) Ltd., Howrah (xii) M/s G.K.W. Ltd., Howrah (xiii) M/s Pankaj International, Ludhiana (xiv) M/s Bharat Industries, Howrah (xv) M/s Precision Auto Engineers, Ludhiana (xvi) M/s J.C. Fasteners Limited, Rohtak (xvii) M/s DFL International Limited, Ludhiana (xviii) M/s Remax (India), Ludhiana (xix) M/s Bharati Overseas, Ludhiana (xx) M/s Anishika Fasteners Pvt. Ltd., Nagpur (xxi) M/s Precision Fasteners Limited, Mumbai (xxii) M/s HR Steel Industries, Howrah (xxiii) M/s.N.L.EngineersPvt.Ltd., Mohali (xxiv) M/s. G.S. Castings, Kurukshetra (Haryana) (xxv) M/s. Nishant Steel Industries, Ludhiana (xxvi) M/s. Anand Bolts, Ludhiana. (xxvii) M/s. A.R.Fasterners,Mohali (xxviii) M/s. Protech Galvanisers& Fabricators P.Ltd, ,Faridabad (Haryana)- (xxix) M/s Roshan Implex Pvt. Ltd., Ludhiana (xxx) M/s Indian Steel and Wire Products Ltd. , Jamshedpur (xxxi) M/s. Namdhari Industrial Traders Pvt. Ltd. Ludhiana
6.	Washers/ Washers Spring	(i) M/s. Nexo Industries Pvt. Ltd., Ludhiana (ii) M/s. Springlock Industries, Vadodara (iii) M/s. Chempromech Engineers, Nagpur (iv) M/s. Forbes & Gokak Ltd., Mumbai (v) M/s. Navin Metal Industries, Kolkata (vi) M/s. Forex Fasteners, Ludhiana. (vii) M/s. Ravi Engineers, Amritsar (viii) M/s Roshan Implex Pvt. Ltd., Ludhiana (ix) M/s Pankaj International, Ludhiana

		(x) M/s Millenium structures(India) Ltd., Indore (xi) M/s. Anand Bolts, Ludhiana. (xii) M/s. A.V. Forgings, S.A.S. Nagar, Mohali. (xiii) M/s. Garg Fasteners, Sherpur, Ludhiana. (xiv) M/s.N.L.EngineersPvt.Ltd.,S.A.S.Nager, Mohali (xv) M/s. G.S. Castings, Kurukshetra (Haryana) (xvi) M/s. Royal Spring Lock Industries Ludhiana (xvii) M/s. Namdhari Industrial Traders Pvt. Ltd. Ludhiana
7.	Forged items (D shackles, Hangers, U-Bolts) & Foundation Bolts & Nuts	(i) M/s. EMI, Thane (ii) M/s. Z.M. Engg. works, Mumbai (iii) M/s. Modern Engineering Works, Mumbai (iv) M/s. General Forging Works, Mumbai. (v) M/s. Aisha Transmission, Jaipur (vi) M/s Trans Accessories Forging Co. Mumbai (vii) M/s Essar Forgings, Boiser (viii) M/s MAN Structural Pvt., Ltd., Jaipur (ix) M/s. Skipper Limited, Kolkata (WB) (x) M/s Reliance Fabricators, Jaipur
8.	220/132kV Transmission line tower	(i) M/s. Skipper Limited, Kolkata (WB) (ii) M/s.ShriAshutosh Engineering Industries (Prop. ShriAshutosh Structures Pvt. Ltd.), RAIPUR (CG) (iii) M/s. N.L.Engineers Pvt. Ltd., Mohali (Near Chandigarh) (iv) M/s. BST Infratech Limited, Kolkata (WB) (v) M/s MAN Structural Pvt., Ltd., Jaipur (vi) M/s. SoluxGalfabPvt.Ltd. Kolkata. (vii) M/s. VarsanaIspat Ltd., New Dehli (viii) M/s. ShriKranaUrja Project Ltd. Jaipur. (ix) M/s. Advance Steel Tubes Ltd. Haridwar. (x) M/s. VSP Enterprises Pvt. Ltd. Haryana. (xi) M/s. Namdhari Industrial Traders (P) Ltd., Ludhiana. (xii) M/s. Unique Structures & towers Ltd. Bhilai. (xiii) M/s. Linkson International Limited, Nagpur.
9.	GSS Earth Wire	(i) M/s. Himachal Wire Industries Pvt. Ltd., Damtal (Kangra). (ii) M/s BAJRANG WIRE PRODUCTS (India) Pvt. Ltd., Jaipur . (iii) M/s.NirmalWires Private Limited, KOLKATA (iv) M/s.Kritika Wires Private Limited, Kolkata. (v) M/s Geekay Wires Hyderabad (vi) M/s Bedmutha Industries Limite, Nasik
10.	ACSR Conductor	(i) M/s AGARWAL GENERAL ENGINEERING WORKS (P.) LTD., JAIPUR (ii) M/s PREM CABLES (P) LTD., PIPALIA KALAN, PALI (iii) M/s VENKATESWARA WIRES PVT. LTD., JAIPUR (iv) M/s RAJASTHAN CABLES &CONDUCTORS PVT. LTD., JAIPUR (v) M/s NECCONPOWER & INFRA LIMITED, JAIPUR (vi) M/s LUMINO INDUSTRIES LTD., KOLKATA (vii) M/s DYNAMIC CABLES LTD., JAIPUR (viii) M/s JSK Industries Pvt Ltd., Mumbai (ix) M/s Rajasthan Transmission Wires Pvt. Ltd., Jaipur (x) M/s Oswal Cables Pvt. Ltd., Jaipur (xi) M/s Mahaveer Transmission Ltd. Dehradun.
11.	24 Fiber(DWSM)OPGW Fibre optic cable/ H/w	(i) M/z ZTT Gurgaon

	set /Joint Box	(ii) M/s Sterlite Technologies Ltd. Silvasa
12.	Obstruction Light (1MED+2LOW Intensity)/ Span Marker	(iii) M/s AvidsTechnovators Pvt. Ltd. New Delhi (iv) M/s. Geolights Pvt. Ltd.New Delhi

4.0 TYPE TEST

- 4.1 Each equipment / item offered for supply against this specification shall be of a design which is already type tested as per the latest relevant standards and the requirements specified in this specification.
- 4.2 In the event of Order, the Contractor shall furnish the latest type test certificates from a Govt. / a Govt. approved /a Govt. recognized / NABL accredited laboratory / ILAC i.e. International Laboratory Accreditation Co-operation (in case of foreign laboratories) or the certificate of type test conducted at manufacturer's works duly witnessed by representative of any Electricity Board / Nigam / Govt. agency / PGCIL / NTPC or the certificate of type test conducted in the manufacturer's own lab located in the foreign country duly witnessed by independent agency (wherever specified in Technical Specification for particular item) for all the type tests wherever prescribed in the relevant latest editions of Indian Standards / International Standards, for approval. The type test certificates should not be older than 07 (SEVEN) years as on the date of Technical bid opening for which the date of conducting of test shall be considered. However, no separate type test charges shall be paid to the bidder.
- 4.3 Type test reports as per Clause 4.2 above for equipments / items manufactured by any of the approved vendors need not be submitted along with the offer. The type test reports shall be submitted for approval to RVPN at the time of drawing approval of equipment / item. Any delay on account of furnishing type test reports for approval shall not be considered for extension in completion period of the project.
- 4.4 If the type tests are more than seven year old then the bidder has to arrange for type testing the equipment/item at no extra cost to RVPN.
- 4.5 Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to RVPN.
- 4.6 Notwithstanding anything stated above, the RVPN's decision regarding type tests will be final and binding on the bidder.

SECTION-II

TECHNICAL SPECIFICATION OF LINE EQUIPMENT/MATERIAL

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TECHNICAL SPECIFICATION FOR SUPPLY, ERECTION, TESTING AND COMMISSIONING OF TRANSMISSION LINES ON SUPPLY & ETC BASIS

1.0 SCOPE

- a) This specification covers for erection and commissioning of transmission lines covered in the **specification on Turnkey basis** i.e. fabrication, galvanization and delivery of the transmission line supporting structure(towers) for 220KV lines complete in all respect including U-bolts with nuts, hangers with nuts and bolts, D-Shackles, with nuts and bolts, links, bird guards, **bird flappers (if identified) during the ESAI study (if conducted) or mentioned in Approvals to be received from Forest Department for given line sections as a necessary** accessory, anti-climbing devices, flat washers etc. The scope also covers supply of other line material like insulator, hardware, accessories, nuts, bolts, ACSR Zebra ,OPGW etc. (as per the bidding schedules) and also survey, check survey, foundation, erection, testing and commissioning of 220kV transmission line.

The bidder shall fabricate proto type towers, one each of all types of required towers, body extensions & stub setting templates and get inspected for checking of fabrication accuracy i.e. dimensions and angles etc. and workmanship by the purchaser's representative.

- b) The provisional quantities of fabricated & galvanized steel, bolts and nuts as per specification required for towers, concrete, excavation volume and reinforcement steel for foundation and other items are given in the respective price schedule. However the work shall be executed as per approved construction drawings.
- c) The various works are described in the various chapters of this specification.
- d) The unit rates quoted shall include minor items/details which are obviously and fairly intended, and which may not have been included in these documents but are essential for the satisfactory completion of the various works.
- e) The unit rate quoted shall be inclusive of deployment of all plant equipment, men, material, skilled and unskilled labour etc. essential for satisfactory completion of various works.
- f) All measurements for payment shall be in S.I units. Lengths shall be measured in meters corrected to two decimal places. Areas shall be computed in square meters and volume in cubic meters, rounded off to two decimals.
- g) The item of pack washers, D-shackles, hangers and special bolts shall be the part of the tower material.
- h) The scope of bidder also includes manufacturing, engineering, inspection at manufacturer's works for supply of material at site i.e. Disc insulators/Long Rod Insulators, hardware fittings for conductor and other line accessories etc.

Supply of 48/24 Fiber (DWSM) OPGW fiber optic cable, Joint box (48/24 Fiber), Hardware set for 48/24 Fiber OPGW Fiber Optic cabling including all cable fittings & accessories, and other line accessories,

Bidder shall clearly indicate in their offer, the source from where they propose to procure these materials. However, the overall responsibility shall be of the Contractor and he shall be responsible for the quality and workmanship of the material etc.

- i) All the raw materials such as steel, zinc for galvanizing, reinforcement steel and cement for tower foundations, coke and salt for tower earthing etc., bolts, nuts, washers,D-Shackles, hangers, links, danger plates, phase plate, number plates, circuitplates, bird guard, anti-climbingdevices etc, required for tower manufacture and erection shall be included in the Contractor's scope of supply. Bidder shall clearly indicate in the offer, the sources from wherehe proposes to procure the raw materials and the components.

2. STANDARDS:

The Indian Standard Specifications (IS) mentioned below as amended upto date shall be applicable for the materials to be utilized on 220 kV and 132kV transmission line on self-supported structure on turnkey basis:

S.No.	Indian Standard	Title
1	IS:2062-1988	Weldable structural steel.
2	IS:802	Code of practice for use of structural steel in Overhead transmission line Towers (part-I-Load and Permissible Stresses. Part-II-Fabrication galvanizing, inspection and packing, Part-III-Testing).
3	IS:808	Dimensions for hot rolled steel beam, column channel and angle sections
4	IS:4759-1968	Hot-Dip Zinc Coating on Structural Steel and Other Allied Products.
5	IS:6639	Hexagonal bolts for steel/IS: 12427 structures/transmission tower bolts.
6	IS:12427	Transmission tower bolts.
7	IS:10238	Stay bolts for steel structures.
8	IS:1367	Technical supply conditions for threaded steel fasteners.
	Part-III	Mechanical properties & Test methods for bolts, Screws & studs with fully load ability.
	Part-VI	Mechanical properties & Test methods for nuts with full load ability.
9	IS:2016	Plain Washers.
10	IS:5369	General requirement for plain washer and lock washers.
11	IS:4072	Steel for spring washers.
12	IS:3063	Single Coil Rectangular Section, Spring Washers for Bolts, Nuts & Screws
13	IS:6821	Methods for sampling Non-threaded washers
14	IS:1573	Electro plated coating for zinc on iron and steel
15	IS:2486	Insulator fittings for Overhead tower lines with nominal voltage greater than 1000V(Part-I general requirements and tests, Part-II dimensional requirements, Part-III locking devices, Part-IV tests for locking devices).
16	IS-2004	Carbon steel forging for General engineering purposes
17	IS-2633	Methods of Testing Uniformity of Coating on Zinc Coated Articles.
18	IS-2121	Conductors and earth wire accessories for overhead power lines(Part-I armour rods, binding wires and tape for conductors, Part-II mid span joints and repair sleeves for conductors.
19	IS-9708	Stock-bridge vibration dampers for overhead lines.
20	IS-731	Porcelain insulators for Overhead power lines with nominal voltage of greater than 1000 V.
21	IS-3188	Characteristics of string Insulators units.
22	IS-2141	Galvanized stay string.
23	IS-398	Aluminum conductors for Overhead transmission purpose(Part-II Aluminum conductors, galvanized steel reinforced.
24	IS-4826	Hot dipped galvanized coating on ground steelwires.
25	IS-209-1979	Specification for zinc.
26	IS-432-1982	Mild Steel Medium Tensile Steel Bars and Hard Drawn Steel Wire for Concrete Reinforcement.
27	PART - I	Mild Steel and Medium Tensile Steel Bars.
28	IS-456-1978	Code of Practice for Plain and reinforced concrete.
29	IS-1200-1974	Method of Measurement of Building and Civil Engineering

		Works.
30	IS-2551-1982	Danger Notice Plates.
31	IS-2629-1966	Recommended Practice for Hot-Dip Galvanising of Iron& Steel.
32	IS-4091-1979	Code of Practice for Design And Construction of Foundations for Transmission-Line Towers and Poles.
33	IS-5358-1969	Specification for Hot Dip Galvanized Coating to Fasteners.
34	IS-5613	Code of Practice for Design,Part-2Installation and Maintenance Section 1&2of Overhead Power Lines.1975
35	IS-6610-1972	Specification for Heavy Washers for Steel Structures.
36	IS-6745-1972	Specification for Methods for Determination of Weight of Zinc Coating on Zinc Coated Iron and Steel Articles.
37	IS-7215-1974	Specification for Tolerance For Fabrication of Steel Structures.
38	IS-8500-1977	Specification for Weldable Structure Steel (Medium and High Strength qualities).
39	IS-388-1970	Course and fine aggregates from natural sources for concrete
40	IS-800-1962	Code of practice for use of structural steel in general building construction.
41	IS-1139-1966	Hot rolled mild steel, medium tensile steel and high yield strength steel deformed bars for concrete reinforcement.
42	IS-1736-1966	Cold twisted steel bars for concrete reinforcement.
43	IS-1873-1967	Criteria of earthquake resistant design of structures
44	IS-2131-1967	Method of standard penetration test of soils.
45	IS-3043-1972	Code of practice for earthing (with amendments no.1&2).

3. PRICES:

The bidder shall quote rate/prices on firm price basis as detailed in Price BOQs of the specification.

4. QUANTITIES AND WEIGHTS

- 4.1 The provisional quantities required are mentioned in the respective schedule of prices. The final quantities of the tower and other line material shall be confirmed by the owner based on the exact requirement furnished by the contractor after completion of final/detailed survey, duly authenticated by concerned S.E (T&C).

On completion of the works, all surplus material, equipment's supplied by the contractor at site against construction of 220kV transmission line, if not required by the purchaser, shall be lifted by the contractor at his own expenses and cost. RVPN shall not be insisted upon by the contractor for taking over of the surplus material supplied, if not required by the purchaser. Excess payments released if any towards surplus material to the contractor shall be recovered by the RVPN from the contractor. Surplus material shall be lifted back by the contractor after recovery of payment released, if any, towards surplus material by the RVPN.

5. MATERIAL:

All line materials to be used in erection of transmission lines shall conform to the relevant standards given in clause No.2 and shall be subjected to inspection and testing as per relevant ISS by the purchaser's representative prior to despatch.

6. TOWERS:

6.1 TYPES OF TOWERS:

6.1.1 The type of Normal towers (normal span of 350 Meters for 220 kV transmission lines and 335 Meters for 132 kV transmission lines), Narrow base towers (Normal Span of 350 (D/C & S/C)/250 (D/C) Meters for 220 Kv Transmission lines and 150 Meters for 132 kV Transmission lines) that shall be used are specified below:

- | | | |
|----|--|--|
| a) | Tower type 'A' tangent tower with suspension strings | These are tangent towers for use on straight run and also for line deviation up to 2 deg. |
| b) | Tower type 'B' Medium angle with tension strings | These towers are for use up to 15 deg. line deviations. |
| c) | Tower type 'C' Medium angle with tension strings | These towers are for use up to 30 deg. line deviation. In case of 250 meter for 220 kV D/C and 150 meter for 132 kV D/C narrow base towers are for use on dead ends and up to 60 deg. line deviation |
| d) | Tower type 'D' Large angle with tension strings | These towers are for use on dead ends and up to 60 deg. line deviation. |

However these towers can also be used for longer span with small deviations.

e) 220kV D/C Special structure:-In addition to the standard towers, and extension, special River/Line Crossing towers are also required.

6.2 WEIGHTS :

The unit weight of each type of tower, Extensions, +3M & +6M Extn. and stub setting templates has been indicated in the specification shall be the ceiling weights for payment purposes. The bidders are required to quote per Tower rate with fabrication, galvanization and supply of these towers on F.O.R. Destination basis.

6.3 DRAWINGS :

- i) Drawings of stubs, super structures, + 3 M & +6 M extension, stub setting templates and tower accessories etc. of all types shall be made available to the successful bidders who shall develop the shop drawings of individual members based on these drawings.
- ii) Standard drawings of all other line materials which have been enclosed with the specification, the line material will be supplied accordingly.

6.4 FABRICATION AND WORKMANSHIP:

The fabrication of towers shall be in accordance with the following:

- i) All parts of the towers shall be fabricated in accordance with the shop drawings prepared on the basis of structural Drawings to be supplied by the purchaser. Shop drawings, containing complete information necessary for fabrication of the component parts of the structures shall be prepared. These drawings shall clearly show the member sizes, length and back marks hole positions gauge lines, bend lines, edge distances, amount of clipping, notching etc.

- ii) In the case of members to be bended the shop drawings will indicate provision for the variation in length to be made.
- iii) Tower shall be bolted construction. Unless otherwise specified, welding at any point shall not be permitted.
- iv) Normally butt splices shall be used and thickness of the inside angle cleat shall not be less than that of the heavier member connected, lap splices may be used for connecting members of unequal size and the inside angle of lap splice shall be grounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the members connected through bolts. But as well as lap splices shall be made above and as close to the main panel points as possible.
- v) No bolt holes shall be more than 1.5 mm larger than the corresponding bolt diameter.
- vi) Workmanship and finish shall correspond to the best modern transmission line practice. All similar parts shall be made strictly interchangeable. All steel sections before any work is done on them shall be carefully leveled, straightened and made true to method which shall not injure the material so that when assembled the adjacent surfaces are in close contact throughout. No rough edges shall be permitted anywhere throughout the work.
- vii) Cutting may be affected by shearing, cropping, flame cutting or sawing. The surfaces so cut shall be clean, smooth, reasonably, square and free from any distortion.
- viii) The other details shall be as per IS: 802(Part-II)-1978.

6.5 DRILLING AND PUNCHING:

- 6.5.1 All steel sections before any cutting work is started shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued up after being punched and drilled. No rough edges fresh from shears shall be left. All sheared and cut ends shall be flamed off.
- 6.5.2 Holes for bolts shall be drilled or punched to jig, but drilled holes shall be preferred. All holes in material over 12 mm thick must be drilled through the plates and sections forming the joint in one operation. The holes near the bend line of a bent member, on both sides of bend line, shall be punched/drilled after bending and relative position of these holes shall be maintained with the use of proper template/jigs and fixtures.
- 6.5.3 Punched holes must be square with the plates and the walls of the holes parallel. The following maximum tolerance in accuracy of punched holes is permissible.
 - i) Holes must be perfectly circular and no tolerance in this respect is permissible.
 - ii) The maximum allowable difference in diameter of the holes on the two sides of plates or angles is 0.8mm i.e. the allowable taper in a punched hole should not exceed 0.8mm on diameter.
 - iii) Holes must be square with the plates or angles and plate holes will not be permitted. All burrs left by drill or punch shall be removed completely. The bidder shall state clearly the extent of punching covered by this tender. When the tower members are in position, the holes shall be truly opposite to each other. Drifting or reaming to

enlarge defective holes shall not be permitted. Minimum edge distance from the centre of any holes shall not be less than what has been indicated in IS 802 Part-II 1978. Bolt holes whether punched or drilled must be larger than the sizes of bolts they have to take, and shall not be more than 1.5mm larger in diameter than the diameter of the bolts.

6.6 ERECTION MARK:

Each individual tower member shall carry a code number conforming to the component number given to it in the fabrication drawings. The code number of approved sizes shall be stamped with a metal die on the member before galvanizing and shall be legible after galvanizing. The letter A, B, C&D indicating the different types of towers shall precede the code number.

6.7 GALVANISING:

All members of the tower and special structures shall be fully galvanized. Galvanizing shall be done after all fabrication work is completed. Galvanizing of the members of the tower shall conform to IS-4759-1968. Bolts & other fasteners shall be galvanized in accordance with IS-5358-1969 and spring washers shall be galvanized in accordance with IS-1573-1979.

6.8 PACKING:

The material shall be boxed or bundled for transport in following manner.

- a) Angles shall be packed in bundles securely wrapped four times around at each end and every feet with No.9 SWG. gauge wire with ends twisted tightly. Gross weight of any bundle shall not exceed approximately 450 kg and the length of any individual member 6000mm.
- b) Cleat angles brackets, fillers, plates and similar small loose pieces shall be rested and bolted together in multiple, and securely wires together through holes, wrapped round at least four times with No.7 SWG gauge wire and ends twisted tightly, Gross weight of any bundle shall not exceed approximately 70 kg.
- c) Flat washers & other attachments such as hangers, U-Bolts, D-shackles, etc. shall be packed in double gunny bags accurately tagged in accordance with the contents.
- d) The packing shall avoid losses/damages during transit.

6.9 MARKING AND PACKING:

6.9.1 Each bundle or package shall have the following marking on it:

- a) The detail and designation of the consignee (to be intimated by the purchaser.)
- b) Ultimate destination as required by the purchaser.
- c) The relevant marks and number of tower members, or reference number of small components like gusset plates, various attachments, etc., for each identification.

6.9.2 The marking shall be stenciled in indelible ink on the top members in the bundles of tower steel and on wooden boxes or gunny bags containing smaller components. Detailed despatch instructions shall be asked for by the

Contractor from the Departmental at least four weeks ahead of the scheduled date of despatch.

6.10 DELIVERY:

The delivery shall be acceptable only in terms of supply of complete towers including footings, superstructures and tower accessories such as hangers, U-bolts, links, D-Shackle & Pack washers etc. including Bolts-Nuts, Step Bolts and spring washers required for towers.

The supply of the line material shall be in the following sequence:

- i) Complete footing and stub setting template with bolt nuts & spring washers.
- ii) Earthing material.
- iii) Complete super structure including extensions & accessories with bolts, nuts, spring washers, step bolts & bird guards. In no case the above sequence shall be changed.
- iv) Danger plates, number plates, circuit plates, phase plates.
- v) Conductor, Insulators, accessories and hardware for conductor and **OPGW (24/48 Fiber)**.

7. FASTENERS AND JOINTS

- a) It shall be ensured that the fasteners provide positive attachment at all times and under the conditions when the tower structures are subjected to vibrating loads.

b) BOLTS

- i) All bolts and nuts shall conform to IS:6639. All bolts and nuts shall be galvanised and shall have hexagonal head being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.
- ii) The bolt shall be of 16mm dia and of property class 5.6 as specified in IS:1367 (Part-III) and matching nut of property class as specified in IS:1367 (Part- VI).
- iii) Bolts up to M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 310 MPa minimum as per IS: 12427. Bolts should be provided with washer face in accordance with IS: 1363 Part-I to ensure proper bearing.
- iv) To ensure uniformity of galvanizing, bolts and nuts should be galvanized by high temperature hot-dip galvanizing, at a minimum temperature of 530 deg. C. The temperature should be recorded continuously in the form of a continuous chart. The galvanized coating should be uniform and its value should be between 50 micron to 115 micron to be checked on random sampling basis, on the threaded portion as well. The facility to check the galvanized coating should be by metallographic method.
- v) Nuts should be double chamfered as per the requirements of IS:1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4mm oversize on effective diameter for size upto M16.
- vi) Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.

- vii) All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further, it shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and more than 8mm when fully tightened. All nuts shall fit and tight to the point where the shank of the bolt connects to the head.
- viii) Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24mm bolt.

c) **HOLES FOR BOLTING**

Holes shall be cylindrical. Oval or lobed forms of holes shall not be permitted. The diameter of the holes shall be equal to the diameter of the bolt plus 1.5 mm. Holes shall be perpendicular to the plates of angles. The accuracy of the location of holes shall be such that for any group of members when assembled the holes shall admit the bolts at right angle to the plane of connection.

d) **SPACING OF BOLT AND EDGE DISTANCES**

The minimum spacing of bolts and edge distances shall be as given below :

Bolt dia (mm)	Hole Dia (mm)	Minimum bolt spacing (mm)	Minimum edge hole center to rolled or sawn edge (mm)	Distance of hole center to sheared or flame cut edge (mm)
16	17.5	40	20	23
20	21.5	48	25	28

However, maximum possible edge security shall be used for single holes of larger section.

e) **LOCKING DEVICES**

Electro galvanized spring washers of type B of thickness indicated below corresponding to bolt diameter shall be provided for insertion under all nuts:

Bolt dia (mm)	Thickness of spring washers (mm)
16	3.5
20	4.0

- f) To obviate bending stress in bolts or to reduce the same to a minimum, no bolts shall connect aggregate thickness of more than three times the bolt diameter and also the number carrying stress to be connected by a single bolt shall not generally exceed three(excluding gusset and packing plates).

g) **TOLERANCES**

- i) Fabrication tolerances in general shall conform to IS:7215 unless otherwise specified hereunder:
- ii) The maximum allowable differences in diameter of the holes on the two sides of the plate shall be 0.8 mm i.e., the allowable taper in a punched hole shall not exceed 0.8 mm on diameter.
- iii) Tolerance cumulative and between consecutive holes shall be within ± 1.6 mm.
- iv) Tolerance on gauge distance shall be within ± 0.5 mm.

8. **BILL OF MATERIAL**

The contractor shall furnish to the Purchaser for approval the various bills of materials.

9. AVIATION REQUIREMENTS

- a) Visual aids shall be provided on the transmission line and transmission line structures of height 45 M and above to give warning to flying aircraft about the presence of transmission line and transmission line supports in compliance to the requirement of IS:5613 (part-3/sec.1) 1989 (amendment No.1, July 1994). According to this purchaser shall have to comply with the following:
- b) i) The transmission lines and transmission line structures of height 45 m and above shall be notified to the Directorate of Flight Safety (DFS), Air Headquarters (Air HQ), New Delhi.
- ii) For construction of any transmission line/ structure or a portion thereof, falling within a radius of 20 km around the Defence aerodromes and air to firing ranges provisions of the Aircraft Act 1934, Section 9A as amplified by the associated Gazette Notification SO 988 Part II, Section 3, Sub section (ii) dated 1988-03-26 shall be complied with. Towards this, a No Objection Certificate (NOC) shall be obtained from the concerned aerodrome authorities.
- iii) Within a radius of 10 km around aerodromes and air to ground firing ranges, all transmission lines and structures of height 45 metres or more shall be provided with day and night visual aids.
- iv) In all other areas, outside a radius of 10 km, from aerodromes, only those portions of transmission lines and structures of any height identified to pose a hazard to aircraft by the Directorate of Flight Safety shall be provided with day visual aids.

c) DESCRIPTION OF VISUAL AIDS

DAY MARKING

- i) Line markers: Coloured globules of 40-50 cm diameter made of reinforced fiber glass or any other suitable material, weighing not more than 4.5 Kg each, with suitable clamping arrangement and drainage holes shall be installed on earth wire(s) in such a manner that the top of the marker is not below the level of the earth wire. Up to 400 metre span, one globule shall be provided in the middle of the span on the highest earth wire. In case of double earth wire, the globule may be provided on any one of them. For span greater than 400 metres, one additional globule may be provided for every additional 200 metres span or part thereof. Half orange and half white coloured globule shall be used.
- ii) Structure Marking: The structure portion excluding cross arms above 45 m height shall be painted in alternative bands of international orange and white colours. The bands shall be perpendicular to the vertical axis and the top and bottom bands shall be orange. There shall be an odd number of bands. The maximum height of each band shall be 5 M.

NIGHT MARKING

Medium and low intensity obstacle lights on a complex obstacle such as towers supporting overhead wires should have a night time intensity as per ICAO requirements in International Standards recommended practices. The light on top of the structure should flash at the rate of 20 sequences per minute.

- d) The contractor shall arrange required data and documents and will assist in preparation/completion of the case to be submitted to the appropriate aviation authorities for obtaining the No Objection Certificate and shall also extend all help in getting the NOC.

e) VISUAL AIDS (TO BE PROVIDED)

(A) Day Markings:

a) Painting of Tower:

The portion of the towers(excluding cross arms) above 45m height shall be painted over the etched surface in contrasting bands of deep orange or red and snow white as per site requirement. The band shall be horizontal and minimum three bands shall be provided. The minimum width of the colour band shall be one meter and not more than 5 mtrs. Following procedures shall be adopted for painting of towers.

(i) Surface Preparation

The etching of galvanized surface of erected tower members with wash primer is to be done as per IS: 1477 (part-I) to enhance the adhesion of subsequently applied paint coating. Before applying primer, the tower surface is to be cleaned and it should be free from dust, moisture or any foreign substances. One coat of wash primer is to be applied on the galvanised surface and after this second coat of zinchromate primer to be applied after 6 hours, but not later than 48 hours. The primer to be used shall conform to IS:2074 (with latest amendment).

(ii) Final Painting

Two coats of international deep orange or red and snow white paint (deep orange or red band at the top) at alternate interval (bands) as explained above are to be applied. The painting of towers shall generally conform to relevant provisions in IS: 1477 (Part -II). The synthetic enamel paints to be used for painting shall be in accordance with IS: 2932 (with latest amendment).

b) Line/ Span Markers

Sphere type span marker of 600mm diameter shall be provided on the earth wire. The sphere shall be divided into two parts and one half shall be painted in orange and one half in white. Up to 400 metre span, one globule shall be provided in the middle of the span on the highest earth wire. In case of double earth wire, the globule may be provided on any one of them. For span greater than 400 metres, one additional globule may be provided for every additional 200 metres span or part thereof. The design of the markers and their fixing arrangement should be such that they can withstand the wind pressure and shall not induce excessive amount of vibrational strain on earth wire. Appropriate clamping device of cast aluminium alloy are to be provided for clamping. All bolts & nuts are made from stainless steel. The spheres are hollow and UV protected against fading of colour and weathering. Detail of this arrangement shall be submitted by the Contractor along with Bid.

(B) Night Markers (Obstruction lights)

The scope of night markers covers the design, manufacture, testing at manufacturer's work, if any, supply, delivery, erection, testing and commissioning of medium intensity and low intensity lights along with storage battery & solar panel, control panel, cables, clamps other accessories etc. as per the provision of IS-5613 (Part-II/ Section-1), 1989, amendment No. 1, July, 94 regarding night & day visual aids for denoting transmission line structures as per the requirement of Directorate of Flight Safety.

The detail of each component of medium intensity, low intensity lights & associated accessories to be provided on the towers shall be as per the technical specifications given in the preceding clauses and IS/ICAO, International Standards recommended practices.

One set of Aviation Lights shall consists of one medium intensity light & two/four (as applicable) low intensity lights along with all accessories such as solar panel, control panel, batteries, cables etc.

The low & medium intensity lights, required for each tower shall be operated through a suitable size of common battery bank, solar panel as per requirement of operating voltage & load current of the type of lamps being offered. The lamps shall conform to the ICAO requirement/ relevant BS and shall have weather protection of minimum IP-55 class. The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T. live line, but in no case it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 hrs., the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. Performance certificate of the lamps to be offered shall be furnished by the Contractor.

(i) Medium Intensity Light

Medium Intensity light shall be provided on the top of each tower. The medium light should have a night time intensity as per ICAO requirements in International Standards Recommended Practices. The light on top of the structure should flash at the rate of 20 sequence per minute. The effective intensity during night time for the medium flashing light shall be 1600 CD. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc.

(ii) Low Intensity Lights

Two/ four (as applicable) nos. of low intensity lights are required to be put on each of the towers. Placement drawing for the same shall be submitted by the Contractor. The light shall be stationary lamp with minimum effective intensity of 10 CD of red light. The low intensity lamp shall not generate any R.F. which can interfere with the PLCC signals.

(iii) Storage Battery

Storage Battery required for the above purpose shall be sealed maintenance free, valve regulated lead acid and suitable for mounting on the top of the transmission line towers. Contractor shall offer the most optimum capacity of the Battery Bank at 120 hour discharge rate (considering 80% percentage usage) matching with the load requirement of the type of lamps being offered including any power loss in the associated cables. The battery sizing shall conform to JISC 8707/ relevant Indian Standard or any other internationally recognized standard. The battery shall be hermetically sealed, explosion proof and self-resealing type and free from orientation constraints. The working temperature ranges shall be minimum 0 degree centigrade and maximum 50 degree centigrade. Performance certificate of the offered batteries shall be submitted by the Contractor.

The battery box suitable for mounting on 400kV power transmission tower shall be robust construction suitable to accommodate desired number of SOLAR BATTERIES with proper clearance between the batteries. The sides and the top of the battery box shall be made from MS sheets not less than 14 SWG thicknesses duly mounted on MS angle frame. The bottom of the battery box shall have suitably designed of MS structure to freely hold the total weight of the batteries. The batteries should be placed on insulated base with proper drainage holes. Lifting lugs shall be provided. Dust and vermin proof lockable doors shall be provided for safety and easy access to the batteries for the maintenance. The battery box should incorporate the design for proper ventilation system in order to prevent a gas concentration inside the box. The ventilation opening shall be protected against rain/ splash water and dust. The inside of the battery box shall be lined with insulating polyurethane plating & exterior painting with weather proof polyurethane paint. The cable entry into the battery box shall be through suitable cable glands.

(iv) Solar Modules

Solar module required for the system shall be suitable for mounting on the transmission line towers and shall be designed for high performance, maximum reliability and minimum maintenance and shall be suitably installed on the tower. The solar modules shall be IP 55 grade protection class. These should be highly resistant to water, abrasion, nail, impact and other environmental factors. These should be placed on the tower at a most optimum angle so as to harness the maximum solar energy and facilitate self cleaning and shall conform to relevant Indian/ International Standards. Module mounting frames shall be weather proof suitable for mounting on tall towers. Details of mounting frames shall be furnished by the Contractor. Junction box shall be provided with weather proof hinged lid with provision for cable glands entry and protections grade of class IP-55. The Contractor shall submit the basis of selecting the numbers of solar modules.

The provision for design, supply & erection of mounting arrangements for photovoltaic modules on the transmission towers in a suitable manner to harness maximum solar energy shall be in the scope of the Contractor. Provision for design, supply & erection of resting platform for the erection of battery bank in a closed enclosure with safety arrangement on the transmission

towers shall also be in the scope of the Contractor. The design and load consideration for safety of towers due to additional platform shall be kept in view while designing, selecting the above.

(v) Control Panels.

Control panels shall consist of solar charge controller, flasher unit, sensor, isolator, MCB, Voltmeter, Ammeter and other control gears. Panel enclosure shall be fabricated out of 14 SWG CRCA sheet and thoroughly treated and painted. Suitable neoprene rubber gasket and pad locking device shall be provided and the protection class shall be of IP-55 class. The Solar charge controller shall be most efficient and preferably fully solid state. It shall be provided with protection to load against increase in temperature, surge, automatic low voltage, automatic disconnection, reconnection during high inrush current and normalcy respectively.

The flash regulator shall be provided for regulating light flashing. The same shall be completely solid state and provided with flash rate set points. The protection against overload current shall also be provided. Necessary sensor/ timer shall be provided in the system to "switch on" the light automatically in the evening and poor visibility period and switch off the same during day time and normal visibility period.

(vi) Cable, Cable Glands, Conduits and Accessories

The cable to be supplied and erected shall be of multi strands copper conductor, weather proof, PVC insulated, PVC sheathed, armoured 1.1 kV grade. The same shall conform to IS: 1554. All the cable accessories such as thimble, glands etc. shall be in the scope of supply and erection of the Contractor. Supply and erection of all the PVC conduits and accessories shall be in the scope of the contractor. All the conduit and accessories shall be as per the relevant IS or ISI brand. The inter-connection cable/ conduit will be clamped in a secured manner with the tower members and any interconnection should be made only inside the environmentally protected junction box.

All the installation on the tower shall be securely and earthed with the tower body by using copper braided wire. The cost of the earthing deemed to be included in the cost

(vii) Type Test

The items/equipments should have already been type tested. However, the type test certificates will be reviewed before pre-despatch inspection and fresh type test will not be required where the satisfactory type test certificate are produced by the contractor.

10. PERFORMANCE SCHEDULE

The Bidder shall furnish the details of his performance in respect of the major works carried out by him involving supplies of materials for and/or erection of such EHV lines preferably 220kV lines which are in service, required as per section 3 Vol.-I of Bid Document.

11. GUARANTEED TECHNICAL PARTICULARS:

The technical characteristics of the material offered be as per Guaranteed and other technical particulars indicated in this specification.

12. ACSR ZEBRA CONDUCTOR:-

12.1 ACSR ZEBRA CONDUCTOR:-

1. SCOPE :

This specification provides for the manufacture, testing before dispatch, supply and delivery of Aluminium Conductor galvanised steel reinforced code "**ZEBRA**" as per the details given in Appendix-II (A & B) attached with this specification.

2. STANDARD SPECIFICATION:

The conductor shall comply in all respects except herein otherwise stated with the Indian Standard Specification IS:398 (Part.II) /1996 with latest amendments, if any.

3. LENGTHS :

1. The conductor ACSR "ZEBRA" shall be supplied in the standard length of 1100 meters with $\pm 5\%$ (five percent) tolerance.
- 2 It shall be permissible to supply not more than 10 percent of the length on any one order in random lengths provided further that none of the random length shall be shorter than 50 percent of the standard length.
- 3 Each wooden / Steel drum shall carry only one standard/random length.

4. INSPECTION AND TESTING:

The inspection & testing shall be carried out by the purchaser's representative as per provisions of IS: 398 (Part-II)/1996 with latest amendment if any.

- 4.1 The supplier/manufacturer shall provide all facilities at their works for inspection of at least 5% (five percent) of conductor drums selected at random by the authorized representative of the purchaser for checking/verification of conductor length/manufacturing defects by transferring the conductor from one drum to another empty drum and at the same time measuring the length of the conductor so transferred by means of the meter.
- 4.2 Samples of individual wires (both aluminium and steel) for tests shall be taken before stranding from the outer ends of not less than 10% (ten percent) of wire coils. If samples are taken after stranding then they shall be obtained by cutting 2 m from the outer end of the finished conductor from not more than 10% (ten percent) of finished reels or drums. The sample length so cut and used/ consumed in testing shall not form part of supply and shall not be billed for.
- 4.3 In case shortage in length is found up to 10 meters in a drum during the course of rewinding in pre-dispatch inspection even then the inspection will be carried out by the inspecting officer by reducing this length from each drum of the lot offered for inspection.

TESTS:

Various tests are as under:-

(A) TYPE TESTS:

The bidder shall furnish the following type tests for ACSR ZEBRA along with the offer as per relevant IS: 398 (Part-II) with latest amendments.

- (i) Surface Condition Test
- (ii) Test for ultimate breaking load on stranded conductor
- (iii) Stress-stain test
- (iv) Measurement of diameter of individual aluminium and steel wires
- (v) Measurement of Lay ratio
- (vi) Breaking load of individual wires
- (vii) Ductility test
- (viii) Wrapping test
- (ix) Resistance test
- (x) Galvanizing test

(B) ACCEPTANCE TESTS:

The following shall constitute acceptance tests.

- a) Measurement of diameter of individual aluminium and steel wire:
The test shall be carried out as per IS: 398 Pt.-II with latest amendments.
- b) Measurement of Lay Ratio: The test shall be carried out as per IS: 398 Pt.-II with latest amendments.
- c) Breaking Load Test: This test shall be made on both aluminum and galvanized steel wires.
- d) Ductility Test: This test shall be made on galvanized steel wires only by either of the two tests given in clause No.13.4.1 "Torsion Test" or 13.4.2 "Elongation Test" of the IS-398(Part-II)/1996 and latest amendment if any.
- e) Wrapping Test: This test shall be made on both aluminum and galvanized steel wires.
- f) Resistance Test: This test shall be made as per IS on aluminum wires only.
- g) Galvanising Test: This test shall be made as per IS on galvanized steel wires only.

13. 11 KV DISC INSULATORS BALL AND SOCKET TYPE/PORCELAIN LONGROD INSULATORS:

The disc insulator and hardware shall comply in all respects with the Indian Standard Specifications IS:731/1971 (Second Revision), IS:3188/1980, IS:2486 (Part.I/1971 (First Revision), IS:2486(Part.II/1989 (First Revision) and IS:2486(Part.III/1974), IS:2486(Part.IV/1981) with latest amendments. The galvanization of metallic parts shall conform to IS:2633/1972. The insulator string shall consist of discs (B&S type) of dimensions specified in Appendix-IV(1) for use on 3 phase, 50 cycles power system, long rod insulator shall comply in all respect with IEC:433/1980 and IEC:575/1977 (with latest amendments).

a) TESTING:

Sampling inspection, testing and acceptance of insulators/ Porcelain long rod insulators shall be in accordance with the latest revision of IS:731/1971 and IEC-383 (Pt-I), while that of hardware associated with these discs shall be as per IS:2486 (Pt.I)/1993 (second revision) IS:2486(Pt.II)/1989 (second revision), IS:2486 (Pt.III)/1974 & IS:3188-1980 with latest amendments. Sampling inspection, testing and

acceptance of Porcelain long rod insulators shall be in accordance with the latest edition of IEC:433/1980 & IEC: 575/1977.

b) **DRAWINGS:**

The bidder shall submit detailed drawings along with type test reports not older than 7 years as on date of bid opening, showing design and dimensions along with full particulars of the conductor clamps, the type of the material used for various parts shall be clearly specified on the drawing for approval if not approved already before offering the material for inspection.

The list of tender drawings to be submitted is as follows :

- i) Dimensioned assembly drawings of the complete strings with all fittings.
- ii) Dimensioned drawings for discs.

c) **GUARANTEED TECHNICAL PARTICULARS :**

The number of discs used on suspension strings and the electro mechanical strength has been given in specification. Full guaranteed particulars including dry and wet flashovers, puncture and impulse voltages, corona formation voltages. creepage distances, length of strings, voltage distribution on strings, etc. should be given in the tender as called for in specification.

14. INSULATOR HARDWARES AND ACCESSORIES FOR ACSR 'ZEBRA' SIZE A1 45/3.18MM & STEEL 7/3.18MM, FOR ACSR'PANTHER SIZE A1 30/3.00mm & steel 7/3.00mm.:

The hardware fittings shall comply in all respect with the Indian Standard Specification IS:2486(Part.I, II, III and IV) with latest amendments. All nuts shall be made of material conforming to property clause 4.8 of IS:1367/1967 (first/ revision) with regard to its mechanical properties, cotterspines shall be made of forged steel conforming to clause 2 of IS:2004/1970 (first revision). All ferrous parts shall be hot dip galvanised conforming to IS:2633/1972. Electro galvanised ferrous fittings shall be checked in accordance with IS:1573/1970 (first revision).The hardware fittings are required to be used with disc insulators string units containing insulators of type.B as classified under clause 3 "CLASSIFICATION" of Is:731/1971 and ACSR 'ZEBRA' Conductor specified in IS:398 Pt.II/1976. The conductor accessories shall comply in all respect with IS:2121/1962, IS:2121 (Pt.I & II)/1991 (with latest amendments). Vibration dampers shall comply in all respect with IS:9708/1980(with latest amendments)

15. HARDWARE :

The insulator string hardware fittings shall be supplied complete in all respects and shall include all fittings necessary for composing the insulator strings and include.

Shackles (U clevis) or back for attaching it to the strain plate or hangers supplied with towers.

Conductor suspension or strain claimps suitable for the conductor specified for attaching the conductor to the strings including suitable liners.

Suitable fittings of the ball and socket type of inter connecting individual units, top and bottom clamps.

In case of double suspensions and double tension strings hardware shall also include suitable yoke attachment.

15. STRING INSULATORS FITTINGS:

The material for string insulator fittings (except those specified otherwise) shall be either drop forged steel or heat treated malleable cast iron and shall be hot dip galvanised. All nuts shall be made of material conforming to property clause 4.8 of IS:1367 (first revision). With regard to its mechanical properties. Cotter pins shall be made of forged steel conforming to clause No.2 of IS:2004/1970 (first revision) with latest amendments.

The security pins shall be made of stainless steel of type AISI 302m or 304 or phosphor bronze conforming to IS:7814.

17. SUSPENSION CLAMPS:

The suspension clamps offered shall be made of high strength aluminum alloy and shall be suitable for use with conductor. When wrapped with Anti-vibration device like preformed armour rods. The composition of the alloy shall be declared by the tenderer giving reference to the relevant ISS. The design of clamps shall be such that the effects of vibration on both the conductor and fitting itself, are minimized.

18. TENSION CLAMPS:

The tension clamps shall be made put of high strength aluminium alloy of compression type, suitable for conductor indicated in Appendix.IV. The mechanical efficiency of tension clamps shall not be effected by method of erection involving income alongwith or similar clamp during or after assembly and erection of tension clamps itself. The strain clamp shall have the same conductivity as of the conductor. and shall be of a design that will ensure unrestricted flow of current.

19. ACCESSORIES FOR CONDUCTOR:

a) MID SPAN COMPRESSION JOINTS FOR POWER CONDUCTOR:

This should conform the requirement of IS:2121(Pt.II) /1981 compression type joints shall be offered suitable for the conductor mentioned in Appendix-IV (4).

b) ARMOUR RODS FOR POWER CONDUCTOR:

The armour rods may be performed type and shall be fabricated from aluminum or an aluminum alloy, selected and processed to provide the most effective stress relieving characteristics. In case of aluminum armour rods, the aluminum contents of the material from which the armour rods are manufactured, shall not be less than 99%.

c) REPAIR SLEEVES FOR POWER CONDUCTOR:

The repair sleeves shall be of the compression type and made of aluminum or suitable aluminum alloy having the same conductivity as that of the conductor, with which they are to be used. Normally, repair sleeves are designed to make a good conductor of which not more than one sixth of the strand in the outermost layer have been served.

Repair sleeves shall be designed for installation without passing over and end of the conductor, if separate swage die, other than those required for making compression joints, are needed for installing the repair sleeve, these must be separately indicated and prices entered in schedule.

d) VIBRATION DAMPERS FOR POWER CONDUCTOR :

The vibration dampers shall be of 4R Type conforming to IS:9708/1980 (with latest amendments) and suitable for use with ACSR Zebra / Panther conductor.

e) TESTS:

Power conductor accessories as detailed above shall be subjected to all the tests as prescribed in the relevant clause of IS:2121/1962 (with latest amendments) and IS:2121(Pt.II)/1981.

The bidder shall furnish type test certificates, not older than 7 years as on date of bid opening, for each above items as per relevant clauses of relevant IS.

f) **DRAWINGS:**

The bidder shall furnish the detailed drawings showing design and dimensions of all accessories and hardware's and including their various parts alongwith type test reports not older than 7 years as on date of bid opening for approval if not approved already before offering the material for inspection.

g) **GUARANTEED TECHNICAL PARTICULARS:**

The number of discs used on suspension and tension strings and the electromechanical strength have been given in specification Technical particulars of matching insulators are given in specification and that of conductor in specification. The guaranteed particulars of hardware fittings should be given in the tender as called for in specification.

20. DANGER PLATE, PHASE PLATE, NUMBER PLATE & CIRCUIT PLATE:

a) The relevant ISS to which this material shall conform are indicated as below:

- i) IS:2551/1982(latest) for general checking.
- ii) IS:5/1978(latest) for colourful ready mixed paints and enamels.
- iii). IS:3972(Pt.2/Sec.I)/1985 for resistance to citric acid at room temperature and boiling temperature.
- iv). IS:3972(Pt.22/Sec.2)/1985 for low and high voltage tests for detecting and locating devices.
- v). IS:3972(Pt.1/Sec.I)/1982 for production of specimen testing.

b) **DIMENSIONS:**

S.N o.	Item	Minimum thickness of MS/SMC Plate in mm	Other Dimension (As per drawing enclosed)		Standard
			Length in mm	Width in mm	
1	220kV Danger Plate	1.6	380	320	IS:2551/1982 (latest amended)
2	132kV Danger Plate	1.6	380	320	IS:2551/1982 (latest amended)
3	Phase Plate	1.6	87.5(37.5R+30 +20R)	75 (Dia)	IS:5613/1985 (Pt.2/Sec.I)
4	Number Plate	1.6	200	150	IS:5613/1985 (Pt.2/Sec.I)

c) **GUARANTEED TECHNICAL PARTICULARS:**

The GTP of Danger plate, Phase plate, Number plate & Circuit plate should be given in the tender as called for in specification.

21 SPECIFICATIONS FOR OPGW CABLING AND ASSOCIATED HARDWARE & FITTINGS

21.1 Scope:

The OPGW cable comprises a ground wire (containing aluminium and steel) with optical fibres in the core or first layer. The OPGW cable replaces the normal ground wires and therefore has to fulfill all the electrical and environmental requirements which affect the ground wire. The fittings, accessories to be supplied shall be suitable for the OPGW type. The OPGW Cables will be used on the transmission lines of Voltage upto 220kV/132kV.

The scope covers survey, planning, design, engineering, manufacturing, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, splicing, termination, testing, training, and demonstration for acceptance, commissioning and documentation for OPGW fibre optic cable including all associated hardware, accessories & fittings, Splicing of fibres and Training. In case of length of OPGW to be laid measures more than 250 km. then provision for repeater station is to be made at suitable tower location in consultation with employer.

This section describes the functional & technical specifications of OPGW cabling and associated hardware & fittings.

21.2 Fiber Optic Cabling

In this section of the technical specification, the functional and technical specification of OPGW cable, associated hardware and fittings for the requirement for G.652D Dual window Single Mode (DWSM) telecommunication grade fiber optic cable is mentioned. Bidders shall furnish with their bids, detailed description of the fiber and cable(s) proposed.

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

21.3 Required Optical Fiber Characteristics

The optical fiber to be provided should have following characteristics.

21.4 Physical Characteristics

Dual-Window Single mode (DWSM), G.652D optical fibers shall be provided in the fiber optic cables. DWSM optical fibers shall meet the requirements defined in Table 21-1.

21.5 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fiber shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fiber attenuation characteristics specified in table 21-1 shall be "guaranteed" fiber attenuation of any & every fiber reel.

The overall optical fiber path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Maximum attenuation @ 1310nm: 0.35dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Table 21-1
DWSMOpticalFiberCharacteristics

Number of optical fibers in OPGW	24/48
Fiber Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm ($\pm 0.6\mu\text{m}$)
Cladding Diameter:	125.0 $\mu\text{m} \pm 1 \mu\text{m}$
Mode field concentricity error	$\leq 0.6\mu\text{m}$
Cladding non-circularity	$\leq 1\%$
Cable Cut-off Wavelength λ_{cc}	$\leq 1260 \text{ nm}$
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	$\geq 0.69 \text{ Gpa}$
Attenuation Coefficient:	@ 1310 nm $\leq 0.35 \text{ dB/km}$ @ 1550 nm $\leq 0.21 \text{ dB/km}$
Chromatic Dispersion; Maximum:	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm
Zero Dispersion Wavelength:	1300 to 1324nm
Zero Dispersion Slope:	0.092 ps/(nm ² xkm) maximum
Polarization mode dispersion coefficient	$\leq 0.2 \text{ ps/km}^{1/2}$
Temperature Dependence:	Induced attenuation $\leq 0.05 \text{ dB}$ (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75 \pm 2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB/km}$ @ 1550 nm (75 \pm 2 mm Dia Mandrel), 100 turns; Attenuation Rise $\leq 0.05 \text{ dB/km}$ @ 1550 nm (32 \pm 0.5 mm dia Mandrel, 1 turn; Attenuation Rise $\leq 0.50 \text{ dB/km}$

21.6 Fiber Optic Cable Construction

Overhead OPGW (Optical Ground Wire) is proposed to be installed on the EHV transmission lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirement of all the transmission lines. Normally the tower span of the lines shall not exceed 600Mtr, However, some of the span may be upto around 1000Mtr or More. The exact details shall be collected by the contractor during survey. To meet the overall requirement of the all transmission lines, the contractor may offer more than one design without any additional cost to the employee, in case span length of more than 600Mtr is found during survey.

21.7 Optical Fiber Cable Link Lengths

The Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take

into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

21.8 Optical Fiber Identification

Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bell core GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

21.9 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

21.10 Optical Fiber Strain & Sag-tension chart

The fibre optic cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25 year cable creep.

For the purpose of this specification, the following definitions shall apply:

- For the purpose of this specification, the following definitions shall apply:
- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
- The no fibre strain condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry techniques.
- The Cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable max strain is defined as the maximum strain experienced by the Cable under the worst case loading condition.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- The Ultimate /Rated Tensile Strength (UTS/ RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the

specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT)/max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions mentioned below:

1. 53° C, no wind and no ice
2. 32° C, no wind and no ice
3. 0° C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 0° C, 2/3rd /36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to 600 m or higher span length in the range of 50 m spans. Max. vertical sag, max. tension and max sag at 0° C & no wind shall be considered for in line with the design parameter of transmission line. The typical details are indicated in the Appendices. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines. The Contractor shall submit the stringing chart for review of Employer.

21.11 Cable Materials

The materials used for optical fiber cable construction, shall meet the following requirements:

21.12 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC-794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, no hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulate commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

21.13 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

21.14 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

- (a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.
- (b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

21.15 OPGW cable installation requirements

The OPGW cable shall be installed on 220/132kV transmission lines.

21.16 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 1994. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of buffered optical fibre units embedded in a water tight aluminium/aluminium alloy/stainless steel protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

21.17 Central Fiber Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres

from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials such as stainless steel tube with aluminium or aluminum – clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminum or stainless steel tube with aluminium protective coating. In case of aluminum protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

21.18 Basic Construction

The cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 8.2 OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

21.19 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

21.20 Electrical and Mechanical Requirements

Table 21-2 provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable IS 802:1995 and IS 875: 1987 shall be applied. However the OPGW installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 21-2

OPGW Electrical and Mechanical Requirements

(1)	Everyday Tension	≤ 20% of UTS of OPGW
(2)	D.C. Resistance at 20°C:	< 1.0 ohm/Km
(3)	Short Circuit Current:	≥ 6.32 kA for 1.0 second

21.21 Operating conditions

Since OPGW shall be located at the top of the EHV transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

21.22 Installation

The stringing procedure shall be submitted by the Contractor prior to stringing for Employer's approval. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor.

21.23 Installation Hardware

The scope of supply includes the assessment, supply and installation of all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The Contractor shall determine the exact requirements of all accessories required to install and secure the OPGW. The quantity of hardware & fittings to meet any eventuality during site installation minimum @1% shall also be provided as part of set/Km for each transmission line without any additional cost of employer.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) Suspension Assemblies:

Preformed armour grip suspension clamps and aluminium alloy armour rods/reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 kN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured in accordance with type test procedures specified.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) Dead End Clamp Assemblies:

All dead end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) Clamp Assembly Earthing Wire:

Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) Structure Attachment Clamp Assemblies:

Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) Vibration Dampers:

Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1mtr/sec to 7mtr/sec, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in Vol III.

One damper minimum on each side per OPGW cable for suspension point and two damper minimum on each side per OPGW cable for tension point shall be used for nominal design span of 400 Mtr. For all other ruling span, the no. of vibration damper shall be based on vibration analysis.

Vibration damper clamps shall be made of high strength alloy of type LM-6, it shall be capable of supporting the dampers and prevent damage or chaffing of the conductor during erection and continuous operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands and causing premature fatigue failure of the OPGW cable under the clamp the clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projection grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and design to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanized steel/stainless steel. It shall be of performed and post formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanized in accordance with the recommendation of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanized mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the

damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. the damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5KN and 5KN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The vibration analysis of the system, with and without damper and dynamic characteristic of the damper as detailed in technical specifications shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows

S. No.	Description	Technical particulars
1	Span length in meters i. Ruling design span ii. Maximum span iii. Minimum span	400 Meter 1100 Meter 100 Meter
2	Configuration	As per specifications
3	Tensile load in each	As per Sag tension calculations
4	Armored rod used	Standard preformed armored rods/ AGS
5	Maximum permissible dynamic strain	+/-150 Micro strains

The damper placement chart for span ranging from 100Mtr to 1100mtr shall be submitted by the contractor. Placement chart should be duly supported with relevant technical documents and sample calculations.

The damper placement chart shall include the following

1. Location of the damper for various combinations of span and line tension clearly indicating the no. of dampers to be installed per OPGW cable per span.
2. Placement distances clearly identified the extremities between which the distances are to be measured.
3. Placement recommendations depending on the type of suspension clamp (viz. free center type /armored grip type etc).
4. The influence of mid span compression joint, repair sleeves and armoured rods (standard and AGS) in the placement of damper.

21.24 Fiber Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply to ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 6 fibres

shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

21.25 Optical Fiber Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

- (a) All fibre splices shall be accomplished through fusion splicing.
- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than six (6) fibres shall be installed in each splice tray.
- (d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.
- (e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

21.26 Fiber optic Approach Cables

For Purposes of this specifications, a fiber optic approach cable is defined as the armoured underground fiber optic cable required to connect overhead Fiber optic cable (OPGW) between the final in line splice enclosure on the gantry/tower forming the termination of the fiber cable on the power line and the fiber optic Distribution panel(FODP) installed within the building. The estimated fiber optic approach cabling length requirements are indicated in the appendices. However, the Contractor shall supply & install the optical fiber approach cable as required based on detailed site survey to be carried out by the contractor during the project execution and the Contract price shall be adjusted accordingly.

21.26.1 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

21.26.2 Jacket Construction & Material

The approach cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armoring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure

to ultra-violet light, weathering and high levels of pollutions. The jacket shall conform to ASTM D 1248 for density.

21.26.3 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibers with identical optical/physical characteristics as those in the OPGW cables. The cables core wrap/bedding, and an overall impervious jacket.

21.26.4 Installation of approach cable

The existing cable trenches/cable raceways proposed to be used shall be identified in the survey report. The contractor shall make its best effort to route the cable through the existing available cable trenches, where suitable existing cable trenches are not available, suitable alternatives shall be provided after employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition.

Suitable provisions shall be made by the contractor to ensure adequate safety earthing and insulated protection for the approach cable.

All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the contractor.

21.27 Optical Fiber Termination and Splicing

Optical fiber terminations shall be installed in Fiber Optic Distribution Panels (FODP) designed to provide protection for fiber splicing of preconnectorized pigtailed and to accommodate connectorized termination and coupling of the fiber cables. The Contractor shall provide rack/wall mounted Fiber.

Optic Distribution Panels(FODPs) sized as indicated in the appendices and shall terminate the fiber optic cabling up to the FODPs. The location of FODP rack shall be fixed by the contractor, with the Employer's approval.

21.28 Fiber Optic Distribution Panel

Fiber Optic Distribution Panels is required for each location for termination of fibers in a manner consistent with the following:

- a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pas-through splicing and fiber terminations.
- b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement.
- c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the contractor shall ensure that all FODPs are properly grounded, The FODP shall meet or exceed ingress protection class IP55 specifications.

21.29 Optical Fiber Connectors

Optical fibers shall be connectorised with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fiber optic couplings supplied with FODPs shall be appropriate for the fiber connectors to be supported. There shall be no adapters.

21.30 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

(a) Outdoor Cable Service Loops:

In-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

(b) Indoor Cable Service Loops:

FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.

(c) Fibre Units Service Loops:

For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

(d) Pigtail Service Loops :

Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

(e) Fibre Service Loops :

At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

21.31 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification .The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

21.32 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

- (a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti- corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal- to- paint bond.
- (c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

21.33 Inspection and Testing Requirement

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall furnish all manpower and materials for tests, including testing facilities, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector i.e. Employer's representative.

Acceptance or waiver of tests will not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer representative unless the Employer authorises testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

The Employer also reserves the right to require any retesting of previously approved tests at the Purchaser's expense. However if the retest(s) reveal non compliance to the specification, the Contractor shall bear the expense for the retesting and remedial action.

21.33.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

- (a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.
- (b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings, and labelling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.
- (c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
- (d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
- (e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

21.33.2 Test Plans and Procedures

Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

The Contractor shall submit a Test Schedule for the Employer's approval within three (3) months after the award of contract for all tests. The test schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer's opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid,

effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

21.33.2.1 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for the Employer approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results, and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in Table 21-3.

Table 21-3

Factory & field Test Plan Requirements

Item:	Description:
1.	Test schedule
2.	Record-keeping assignments, procedures and forms
3.	Procedures for monitoring, correcting and retesting variances
4.	Procedures for controlling and documenting all changes made to the communications equipment after the start of testing

21.33.2.2 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 21-4.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ zig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Table 21-4

Test Procedure Requirements

Item:	Description:
1.	Test Title and Revision Level, if applicable
2.	Function(s) / parameter(s) to be tested
3.	Purpose of each test segment
4.	List of required test equipment
5.	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.
6.	Test set up including test configuration block diagrams and/or illustrations.
7.	Test procedures to be followed.
8.	Required inputs and expected outputs for each test segment
9.	Acceptance criteria for each test segment.
10.	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
11.	Format of test reports.

21.34 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 21-5.

**Table 21-5
Test Record Requirements**

Item:	Description:
1.	Test Title and Revision Level, if applicable; contract references
2.	Date and time for test start and test completed
3.	Test title and reference to the appropriate section of the test procedures
4.	Description of any special test conditions or special actions taken (Includes test- case data).
5.	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6.	Test procedure modifications made during testing.
7.	Variance Report(s) tracking information and copies (if variance(s) was detected).
8.	Contractor's test engineer(s) identification, signature and remarks
9.	the Employer's test witness identification, signature and remarks
10.	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test.

These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within 30 calendar days of completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

21.35 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary.

Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

21.36 Test Periods Defined

The terminology used in Volume I, General Conditions of Contract/ Special Condition of Contract and their correlation with the tests requirements described within this section is as follows:

- a. Pre-Commissioning & Commissioning Period - The Site Acceptance Test (SAT)
- b. Operational Acceptance - Completion of "Guarantee Test" as defined

in GCC/SCC, successful completion .of SAT for all FO links and submission of all drawings/documents as per technical specifications requirement.

21.37 Testing Requirements

Following are the requirements of testing under Fibre Optic Cabling Package:

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

21.37.1 Type Testing

Type tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this specification. The test reports for these tests shall be furnished by the contractors as per the requirement of this specification. Type testing shall comply with the following:

- a) All cables & equipment being supplied shall conform to type tests as per technical specification.
- b) The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of techno-commercial bid opening. In case the test reports are older than seven (7) years for OPGW cable on the date of Techno-commercial bid opening, the Contractor shall repeat these tests at no extra cost to the Employer.

21.37.3 List of Type Tests

The Type testing shall be conducted on the following items

- a) Optical fibers
- b) OPGW cable
- c) OPGW cable fittings
- d) Vibration Damper
- e) Splice Enclosure (Joint Box)
- f) Approach Cable

21.37.3.1 Type Tests for Optical Fibers

The type tests listed below in table 21-6 are conducted on DWDM fibers to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

Table 21-6

Type Tests for Optical Fibers

S.No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Specification	IEC60793-1-40 Or EIA/TIA455-78A
2	Attenuation Variation with Wavelength		IEC60793-1-40 Or EIA/TIA455-78A
3	Attenuation at Water Peak		IEC60793-1-40 Or EIA/TIA455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC60793-1-52 Or EIA/TIA455-3A, 2 cycles

5	Attenuation With Bending (Bend Performance)	IEC60793-1-47 OrEIA/TIA455-62A
6	Mode Field dia.	IEC60793-1-45OrEIA/TIA 455-164A/167A/174
7	Chromatic Dispersion	IEC60793-1-42OrEIA/TIA 455-168A/169A/175A
8	Cladding Diameter	IEC60793-1-20OrEIA/TIA455-176
9	Point Discontinuities of attenuation	IEC60793-1-40OrEIA/TIA455-59
10	Core -Clad concentricity error	IEC60793-1-20OrEIA/TIA455-176
11	Fibre Tensile Proof Testing	IEC60793-1-31 OrEIA/TIA455-31B

21.37.3.2 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in table 21-7 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 21-7
Type tests for OPGW Cable

S.No.	Test Name	Test Description	Test Procedure
1	Water Ingress Test	IEEE1138 Section4.1.1.1	IEEE1138,Section5.1.1.1 (IEC60794-1-2MethodF5orEIA/TIA455-82B): Test duration : 24hours
2	Seepage of filling compound	IEEE1138 Section4.1.1.2	IEEE1138 Section5.1.1.2 (EIA/TIA455-81B) Preconditioning period: 72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE1138 Section4.1.1.3	IEEE1138 Section5.1.1.3 Fiber attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
		Or IEC60794-4-10/ IEC60794-1-2(2003) Method H1	Initial temperature during the test Shall be greater than or equal to ambient field temperature.

4	Aeolian Vibration Test	IEEE1138 Section4.1.1.4 Or IEC60794-4-10/ IEC60794-1-2, MethodE19	IEEE1138 Section5.1.1.4	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test..
5	Galloping test	IEEE1138 Section4.1.1.5	IEEE1138 Section5.1.1.5	Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure2inIEC60794-1-2MethodE11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE1138 Section4.1.1.6 Or IEC60794-1-2(2003) MethodE18B	IEEE1138 Section5.1.1.6	Fiber attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. Shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibers of the test cable sample shall be spliced together in serial for attenuation monitoring.

8	Crush Test	IEEE1138 Section4.1.1.7	IEEE1138 Section5.1.1.7 (IEC60794-1-2, Method E3/EIA/TIA 455-41B)	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400- metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured
9	Impact Test	IEEE1138 Section4.1.1.7	IEEE1138,Section 5.1.1.7 (IEC60794-1-2E4/ EIA/TIA 455-25B)	The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius \pm 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.
10	Creep Test	IEEE1138 Section4.1.1.8	IEEE1138 Section5.1.1.8	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be calculated..
11	Fiber StrainTest		IEEE1138 Section4.1.1.9	IEEE1138 Section5.1.1.9
12	Strain Margin Test		IEEE1138 Section4.1.1.10	IEEE1138 Section5.1.1.10
13	Stress strainTest		IEEE1138 Section4.1.1.11	IEEE1138 Section5.1.1.11
14	Cable Cut-off wavelength Test		IEEE1138 Section4.1.1.12	IEEE1138 Section5.1.1.12
15	Temperature CyclingTest		IEEE1138 Section4.1.1.13	IEEE1138 Section5.1.1.13 OrIEC60794-1-2,MethodF1
16	Corrosion(Salt Spray)Test		EIA/TIA455-16A	
17	Tensile Performance Test		IEC60794-1-2E1/ EIA/TIA455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre

			optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.
18	Fault Current/ Lightning Test	IEC60794-4-10/ IEC60794-1-2(2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.
19	DC Resistance Test (IEC60228)	On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.	

21.37.3.3 Type Test on OPGW Cable Fittings

The type tests conducted on the OPGW Cable fittings and accessories are listed below:
The type tests conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16 o(degree) . This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached 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 shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached 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 shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

AcceptanceCriteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
-
- NoevidenceofFractureattheendofoneminuteattheminimumfailureloadduringPart2oftheTest
- .

Anyresult outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

AcceptanceCriteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

* Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.
- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on a 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95 % of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall

be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

21.37.3.4 Type Test on Vibration Damper

(i) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band as determined through vibration analysis of undamped OPGW. The damper assembly shall be vibrated vertically with a ± 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

- (a) Force Vs frequency
- (b) Phase angle Vs frequency
- (c) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

- (i) The above dynamic characteristics test on five damper shall be conducted.
- (ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
- (iii) The above mean reactance response curve should lie within the following limits : V.D for OPGW: $0.060f$ to $0.357f$ kgf/mm Where f is frequency in Hz
- (iv) The above mean phase angle response curve shall be between 25° to 130° within the frequency range of interest.
- (v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
- (vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(ii) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

- (i) The analysis shall be done for single fiber optic cable without armour rods. The tension shall be taken as max Permissible Every Day Tension (20% of UTS), for a span ranging from 100 m to 1100 m.
- (ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.
- (iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.
- (iv) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.
- (v) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
- (h) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

21.37.3.4.1 Vibration Damper Clamp Slip and Fatigue Tests

(i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 15 kN and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Clamp Slip Test

The vibration damper shall be installed on the test span. The damper clamp, after tightening with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of fiber optic cable for a minimum duration of one minute shall not slip, i.e., the permanent displacement between fiber

optic cable and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased until the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

(iii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than $\pm 25/f$ mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein above shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fiber optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fiber optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

- (i) There shall not be any resonant frequency shift before and after the test by more than $\pm 20\%$.

The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than $\pm 20\%$.

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper:

S.No.	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip Test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachment of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

21.37.3.5 Type Tests for Splice Enclosures (Joint Box)

Following Type tests is conducted on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40°C to +65°C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than $\pm 0.05\text{dB}$. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55°C $\pm 2^\circ\text{C}$ with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than $\pm 0.05\text{dB}$, and the internal humidity rate measured, less than 2% .

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than $\pm 0.05\text{dB}$.

(iv) Vibration Test

The splice enclosure, with fibers united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibers, shall be less than $\pm 0.05\text{dB}$. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibers spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

- a) 3 torsion cycles of $\pm 180^\circ$ shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 flexure cycles of the cable, of $\pm 180^\circ$ with one cycle less than one minute.

The variation in the attenuation, of the fibers, shall be less than $\pm 0.05\text{dB}$. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 10 meters of cable fixed to the box, it shall be dropped five times from a height of 11 meters. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test shall be carried out in accordance with procedure described in IEC 60068-2-32.

21.37.3.6 Type Tests for Fiber Optic Approach Cable

The type tests to be conducted on the Fiber Optic Approach cable are listed in table 21-6: Type Tests for Fiber Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 21-6:
Type Tests Fiber Optic Approach Cable

S.No.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles
-End Of Table-		

21.37.3.6.1 Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius $\pm 10\%$. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

21.38 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected Fibre Optic Cable & associated accessories to be supplied. Factory acceptance testing shall be carried out on OPGW cable, hardware fittings & accessories, splice enclosures , etc.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employers approval to ship shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer's representatives is intimated to the Contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the Fibre Optic Cable & associated accessories in relation to this specifications and approved drawings and documents. A list of factory acceptance tests for fibre optic cables, hardware fittings & accessories are given in the Specification. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program.

The factory acceptance tests for the splice enclosures, and other items shall be proposed by the Contractor in accordance with technical specifications, Standards and Contractor's(including Sub-Contractor's /supplier's) standard FAT testing program. For Test equipment, FAT tests shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

21.39 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 1) for FO cable drums, splice enclosures and other similar items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW/ hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

21.40 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

21.41 Factory Acceptance Tests on Optical Fiber to be supplied with OPGW

The factory acceptance tests listed in table 21-8 below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138, 1994. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 21-8
Factory Acceptance Tests for Optical Fibers: Optical Tests

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	TS Vol III ,Table 21-1	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS Vol III, Section 21-5	EIA/TIA 455-59
3	Attenuation at Water Peak	TS Vol III ,Table 21-1	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding diameter		EIA/TIA455-176
7	Fiber Tensile Proof Testing		EIA/TIA455-31B

The test report for the above tests for the fibres carried out by the Fibre Manufacturer and used in the OPGW shall be shown to the inspector during OPGW FAT and shall be submitted along with the OPGW FAT report.

21.42 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table 21-9 follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 21-9

Factory Acceptance Tests On OPGW

Applicable standard: IEEE 1138 / IEC 60794

S.No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

21.43 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 5-10. The sampling plan shall be as per relevant standard:

Table 21-10
Factory Acceptance Tests On OPGW Fittings

S.No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising Test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to the messenger cable
15	Attachments of weights to the messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

21.44 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 21-11:

Table 21-11
Factory Acceptance Tests On Approach Cable

S. No.	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

21.45 Factory Acceptance Test on Splice Enclosure (Joint Box)

The factory acceptance tests for Splice Enclosures as specified below in Table 21-12:

Table 21-12

Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S.No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure and dimensional checks against the approved drawings.

21.46 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment including test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. A minimum Site Acceptance Testing requirement for FO cables is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO cabling installation.

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

21.46.1 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

21.46.2 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and Tension of Aerial cable shall be as per approved sag tension calculation and during installation sag & tension shall be documented.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Tables 21-12 (a) through 21-12 (c).

**Table 21.12(a)
FiberOptic Cable Pre-Installation Testing**

Item:	Description:
1.	Physical Inspection of the cable assembly for damage

2.	Optical fiber continuity and fiber attenuation with OTDR at 1550 nm
3.	Fiber Optic Cable length measurement using OTDR

**Table 21-12(b):
FiberOptic Cable Splicing Testing**

Item:	Description:
1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper fiber / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

**Table 21-12(c)
Fiber Optic Cable Commissioning Testing**

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fiber at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fiber at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

**GUARANTEED TECHNICAL & OTHER PARTICULARS OF
OPTICAL GROUND WIRE (OPGW) – 24/48 Fiber:**

Manufacturer:___ Part#:_____ Configuration: _____

CABLE CONSTRUCTION			
Seq	Parameter:	As per Technical Specification	As per Bidder Offering
1.	No. of Fibers Dual Window Single-Mode:	24/48	
2.	Buffer Type:	Loose Tube	
3.	Buffer Tube material	Non metallic	
4.	No. of Buffer Tubes:	Minimum Two (2)/Four(4)	
5.	No. of Fibers per buffer Tube:	Maximum Twelve(12)	
6.	Expected Cable Life:	25 Year	
7.	Parameters ofOPGW		
(i)	UTS	In Kgf	
(ii)	Effective area	In mm ²	
(iii)	Weight	In kg/m	
(iv)	Diameter	In mm	
(v)	Modulus of elasticity	In kg/mm ²	
(vi)	Coeff. Of linear expansion	In /°C	
(vii)	Central tube design	Al or Steel	

**DUAL-WINDOW SINGLE MODE (DW-SM)
OPTICAL PARAMETERS**

Seq	Parameter:	As per Technical Specification	As per Bidder offering
1.	Fiber manufacturer(s)/Type:		
2.	Attenuation Coefficient@ 1310nm: @ 1550nm:	≤ 0.35 dBkm ≤ 0.21 dBkm	
3.	Point discontinuity @ 1310nm: @ 1550nm:	≤ 0.05 dB ≤ 0.05 dB	
4.	Nominal Mode Field Diameter @ 1310 nm:	8.6 to 9.5 μm (± 0.6 μm)	
5.	Chromatic Dispersion Coefficient @ 1310 (1288-1339)nm: @ 1310 (1271-1360)nm: @ 1550nm:	3.5 ps/(nmxkm) 5.3 ps/(nmxkm) 18 ps/(nmxkm)	
6.	Zero dispersion wavelength:	1300 to 1324 nm	
7.	Cutoff wavelength:	≤ 1260 nm	
Physical and Mechanical Properties			
8.	Bend Performance: (37.5 mm radius, 100 turns)@1310 nm (30 mm radius, 100 turn)@1550 nm (16mm radius, 1 turn) @ 1550nm	≤ 0.05 dB ≤ 0.05 dB ≤ 0.50 dB	
9.	Cladding Diameter (nominal \pm deviation):	125.0 $\mu\text{m} \pm 1$ μm	
10.	Polarization mode dispersion coefficient	≤ 0.2 ps km ^{1/2}	
11.	Proof test level	≥ 0.69 Gpa	

SECTION-III

TECHNICAL SPECIFICATION OF ERECTION,

TESTING & COMMISSIONING FOR LINES

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1. ERECTION AND COMMISSIONING:

1.1 SCOPE:

The erection of LINE covered under this section consist of

- (i) Original and check survey including preparation of profiles.
- (ii) Supply of tower and line materials and transporting to Contractors Stores and kept in safe custody
- (iii) To take suitable Storage cum erection insurance
- (iv) Distribution of all materials to erection site.
- (v) Stub setting
- (vi) Tower erection
- (vii) Stringing of ACSR ZEBRA/ PANTHER Conductor including stringing of conductor from substation gantry to terminal tower at both ends
- (viii) Stringing of OPGW Cable.
- (ix) Testing, commissioning and guarantee of all the activities carried out from (i) to(viii). The erection work shall be carried out as per technical details of this specification.

1.2 The successful contractor shall carry out all addition/alteration required to complete the line for commissioning at the same rates as indicated in schedule.

1.3 The steel required for reinforcement of foundation work shall be arranged by the contractor at his own cost.

2. WAY LEAVE, TREE CUTTING AND OTHER OBSTRUCTIONS :

2.1 The NIGAM will arrange for right of way and clearance for other obstructions, however tree/crop cutting and corridor clearance as per IS-5613 Part-II will be done by the contractor at his own cost. Compensation for tree/crop if any shall be borne by the NIGAM. Proposals for "Right of way" and clearance for other obstructions will have to be prepared and submitted by the contractor well in time. It will also be necessary on the part of contractor to instruct his labours and staff to use minimum area while doing the work where there are standing crops. No person of the Contractor should pick any item from standing crops. The Contractor should take all possible steps to avoid or minimize damage to standing crops, etc.

2.2 The Contractor should immediately notify any obstructions or hindrance from local villagers or the local authorities in the execution of the work, to the concerned Engineer/in-charge but should not deal directly in the matter. The Engineer/ in-charge will arrange to remove the obstacles as soon as possible.

2.3 For the clearance, permissions, removal of obstructions in way leave, etc. the contractor shall not remain contented by simply informing the NIGAM but shall invariably assistant arrange for personal follow up to overcome the difficulties in the interest of progress of the work.

2.3.1 The Contractor shall also identify the forest/non forest areas involved duly authenticated by concerned authorities.

- a) A statement of forest areas with survey/compartament Nos.(all type of forest RF/PF/Acquired forest/Revenue forest/Private forest/Forest as per dictionary meaning of forest etc.)
- b) A statement of non-forest areas with survey/compartament nos.
- c) Tree cutting details (Girth wise & specie wise)
- d) Marking of forest areas with category on topo sheets 1:2,50,000 showing complete line route, boundaries of various forest divisions and their areas involved.
- e) Village forest maps of affected line and affected forest area and marking of the same.
- f) Forest division map showing line and affected forest area.

2.3.2 The Contractor shall finalize the forest clearance proposal on the prescribed format duly completed in all respects for submission by the Employer to the Forest Department.

2.4 ACCESS TO LOCATIONS:

It will be the contractor's sole responsibility to take the material upto the location. Any path way, temporary road, temporary bridge required will have to be provided by the Contractor at his cost. If, for any reason the above is not possible, he Contractor at his own cost shall have to arrange transportation by head loads The Contractor will be deemed to be very well familiar with the route of the Transmission line before giving the offer. Notwithstanding, the difficulties of terrain, location approaches, way leave and other obstructions the price quoted for all the items of erection in the respective Schedule shall not undergo any change at any stage of work (including the time limit extension)

2.5 DISTRIBUTION OF MATERIALS:

2.5.1 The contractor has to take delivery of tower and other materials directly from the carriers or from the NIGAM store, and keep them in safe custody and transport to the respective tower erection site and will be responsible for any damage to or loss of all materials at any stage during transportation or erection. The materials that will be issued by the NIGAM will be in as is where is conditions at the stores centre of the purchaser in the area during working hours.

2.5.2 The Contractor shall take storage cum erection insurance cover for the entire project at his own cost as per respective Clause of this specification.

2.5.3 The Contractor shall submit the complete material account immediately after the work is completed and in any case not later than 3 months of completion and handing over of the line.

2.5.4 So far as the accounting of unused/ surplus tower is concerned, the same shall be done on the basis of completed tower only and not on per MT basis .For shortage of any part of tower (as per Bill of material), Nuts-bolt and accessories to complete the tower , recovery of complete full tower shall be made from the Contractor's bill. At the final accounting the cost of unused material remained with the contractor shall be deducted from the final bill.

3. TESTING AND COMMISSIONING:

After completion of the work, as mentioned in Scope, the Contractor will ensure that all works connected with the line have been completed correctly as per Indian Electricity Rules and procedure. Any extra cost involved due to incompleteness of work or bad workmanship found but subsequently, shall be set right forthwith by the Contractor at his cost. The contractor shall arrange to handover the complete line.

3.1 ELECTRICITY RULES:

All works shall be carried out in accordance with the revised and latest provisions under Indian Electy. Act, and Rules made there under.

3.2 ERECTION TOOLS:

All the erection tools required during construction of lines shall be arranged by the contractor at his own cost. Adjustable stub templates will be supplied by CONTRACTOR which shall be returned by the contractor in good condition on the completion of the work. The Contractor shall be completely responsible for any damage and/or loss of erection tools.

4. PROGRESS REPORT:

Fortnightly progress reports in duplicate shall be regularly submitted to the Chief Engineer (T&C), with a copy to Superintending Engineer(T&C/ Contract-I/II) Executive Engineer (Const.)/ Incharge of works. In this connection, please also refer other clauses of this specification.

5. QUANTITY OF WORK:

The quantities of various items of erection indicated in the respective **Schedule** are tentative. Final quantities shall be determined after completion of detailed route survey. The contractor has to carry out the work according to quantities as determined so as to complete the line for commissioning for which the rates quoted in the tender shall be valid. The payment shall be made only for quantities indicated in the final bill of material approved by the purchaser after completion of the final route survey.

6. CEMENT & R.C.C. STEEL:

6.1 The cement & RCC steel required for foundation shall be procured by the contractor at his own cost. The contractor shall use any one of the following cement make or any other equivalent make as approved by the concerned SE(T&C).

- (a) VIKRAM
- (b) BINANI
- (c) BIRLA UTTAM
- (d) SHREE CEMENT
- (e) J.K. CEMENT

The quantity of cement shall be as per IS 8112:1989 (43 Grade ordinary port land cement specification).

In case of non-availability of 43 Grade OPC cement, contractor can use 53 Grade OPC (IS:12269) in place of 43 Grade OPC. The contractor can also use PPC (Portland Pozzolana cement – IS:1489) with the permission of concerned SE(TCC).

6.2 No price variation shall be applicable on reinforcement steel to be procured by the Contractor.

6.3 The NIGAM reserves right to test the quality of steel & cement procured by the Contractor and intended to be used for the tower foundation works.

7. IMPORTANT:

7.1 The bidder should quote these rates strictly in accordance with commercial terms and conditions for erection of towers and other terms and conditions of this tender specification and they should not quote their own terms and conditions. The bids not falling in line with NIGAM's terms and conditions quoted in the tender, are liable to be summarily rejected.

7.2 In case of any doubt or interpretation of the terms and conditions, the decision of Chief Engineer(Contract), Jaipur will be final and binding to the bidder and no dispute in this regard will be entertained.

7.3 The Bidders should specifically note that the offer containing:

- a) Different rates for the same items i.e. rates quoted in two slabs.
- b) Deviations/addition/alterations/commissions in bidding schedules.

- c) Deviations and contradictions to terms and conditions specified in this tender are liable to be summarily rejected.

8.0 SPECIAL INSTRUCTIONS :

- 8.1 Offer with any change suggested in price variation formula will be out rightly rejected.
(Not Applicable)
- 8.2 The Bidders shall specifically note that the NIGAM will not pay any extra amount towards any type of claim except for the description indicated in erection schedule.
- 8.3 Quantities given in the Schedule (Supply) are tentative and may vary according to requirement of the line to be erected.

9. SCOPE :

- 9.1 Please refer to Clause No.1 of this specification.
- 9.2 The Contractor shall be fully responsible for completing all the above works till they are taken over by the NIGAM.
- 9.3 The methods of erection are not dealt with in details but are left to the Contractor who shall exercise his own judgment with regard to actual handling of materials and in deciding upon the best methods to be adopted in the erection of towers, conductors and other materials.

10. SURVEY & ALIGNMENT:

- 10.1 The tenders are presumed to have acquainted themselves with the route before submitting their offer.
- 10.2 The Contractor shall make a check survey of the line route, which will be shown to the successful tenderer and submit profile and plan drawings showing each and every proposed structure position, length of spans in Meters, clearances and type of structures required. These survey maps shall be prepared to the scale of 20 Meters = 1 Cm, horizontal and 2 Meters = 1 Cm. vertical Deviation point angles should be marked in degrees with

Right Left as the case may be. All Kutcha and metalle roads, trees, structures, Buildings, Canals, wells, river, railway, P&T lines, power line crossings, ponds and other obstructions, etc. within 50 metres on either side of line route should be clearly indicate. These maps should also indicate the profile and level of the proposed route and show the location of the towers with a ground clearance diagram.

- 10.3 Before commencing the check-survey, the Contractor will get from the Engineer-in-charge of the works all the data that have been collected for the proposed routes of the Transmission line, which will be mark on blue prints or topographical sheets. While marking the detailed survey if any better route is found free of roads, telegraph lines, power lines, river and canal crossings, etc. or due to other considerations such as avoiding tanks or reservoirs, etc. the contractor should survey the alternative route at no extra cost. Final approval to the route will be accorded by the concerned Superintending Engineer(TCC), Rajasthan Rajya Vidhyut Prasaran Nigam Ltd.

The successful bidder shall carry out all the erection works in accordance with tower spotting data, structural & foundation drawings, provided by the NIGAM.

- 10.4 On completion of the final survey, the Contractor should submit one tracing and three blue prints copies of final survey to the Superintending Engineer(TCC), before commencement of digging of pits. When the route and profiles are finally approved, no alternative shall be allowed without written consent of the Superintending Engineer (TCC) and the line shall be constructed exactly according to the approved

survey. If any subsequent alternation is found necessary, the Contractor shall have to submit full details of such an alteration with justification and obtain approval of the Superintending Engineer(TCC), before carrying out the work. The contractor will be responsible for any inaccuracies that may arise when finally locating the towers at site and should rectify such inaccuracies at his own cost.

11. STUB SETTING AND FOUNDATIONS:

11.1 The contractor shall be fully responsible for correct setting of stubs in accordance with approved methods at the exact locations and alignments and in precisely correct level. Stub setting templates shall be fabricated by the contractor and same should be used for proper setting of stubs. The contractor will be responsible for constructing the foundations in accordance with the approved design of each type of foundation.

11.2 The foundation work including stone revetment, concrete or earth filling above ground level wherever necessary and stacking and tamping on the site of all surplus excavated soil. Surplus stone should be stacked within the tower base.

11.3 The payment for excavation will be limited to the volumes as per approved excavation drawings even though the contractor may excavate more for the sake of his own convenience. If the excavated depth is more than the depth shown in the approved drawings, the additional depth should be filled in with lean concrete (1:4:8) at contractor's cost in respect of materials, labours etc.

11.4. Classification of soil:

11.4.1 Normal Dry Soil:

The soil readily removable with ordinary spades, pick axe and shovels viz. murrum/sandy etc. and to be used for location in normal dry cohesive or non-cohesive soils of any colour.

11.4.2 Hard soil/ Hard murrum/ Dense soil:

Generally any soil which requires the close application of picks or jumpers or scrifiers to loosen, such as stiff clay, gravel and cobble stone.

11.4.3 Soft rock :

Where decomposed or fissured rock, hard gravel, kankar lime stone, laterite or any other soil of similar nature is met, undercut type foundation is to be used for soft rock locations. The ultimate safe bearing capacity of soil should be 45000kg/m².

11.4.4 Hard rock :

Where cheaseling, drilling, blasting is required and the ultimate safe bearing capacity of soil should be 65600kg/m²

11.4.5 Wet:

i) Where subsoil water is met at 1.5m, or more below ground level.

ii) Which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. the paddy fields.

11.4.6 Fully submerged soil :

Where sub-soil water table is met at less than 0.75 meter below ground level and upto complete depth of foundation.

11.4.7 Partially submerged soil :

Where the sub-soil water table is met between 0.75M to 1.5M below ground level, the top portion of the strata being normal dry soil.

11.4.8 Composite Soils:

Guidelines for adopting various types of foundation in composite soils.

a) On the locations where composite soils are likely to be encountered, excavation shall be done very carefully.

b) The width of the normal soil excavation should be maintained till the layers of soil mentioned under normal soil classification are encountered.

If the layers of soil other than classified under normal soil are encountered, excavation width shall be restricted to minimum till normal soil foundation depth is reached.

c) If the layers of soil other than classified under normal soil are encountered, excavation width shall be restricted to minimum till normal soil foundation depth is reached. After the excavation of all the four pits for the tower as indicated, the Engineer In charge of the work or Engineer nominated by the Superintending Engineer (TCC) from Head office shall decide the type of composite soil foundation to be adopted for the particular location. For this purpose contractor shall offer at least 8 to 10 locations at a time.

12. PROTECTION OF TOWER FOOTING:

- i) Special measures are required for protection of tower footings located close to or in nallahs, river stream beds etc. and subject to approval by the Engineer. The work includes all necessary stone revetment, concreting, earth filling above ground level, providing suitable revetment or galvanized wire netting and meshing packed with boulders. The contractor shall furnish recommendations for providing protection at such locations. The bidders are required to furnish unit rates for such protective works in the price schedules. The unit rates shall be applicable with actual quantities of revetment and extra excavation work done if any.
- ii) On ordinary flat ground, the stubs shall be set with their tops above ground level as per design and given a coping but not marking up of plinths shall be required. Where the ground surface is irregular, the foundation shall be finished off in a substantial and permanent way forming a plinth by soil cutting, building a suitable stone revetment or in case of rock foundations by building up with however, be done after backfilling free of cost.

The bidders are requested to quote unit rates for backfilling with borrowed earth also.

13. GENERAL ON EXCAVATION:

- 13.1 The rates for submerged soil are applicable to all locations, which will be classified as submerged including partially, or fully submerged locations by actual condition. If for the above case, the soil required shoring, shuttering and/or dewatering etc, these will be carried out at no extra cost to the NIGAM.
- 13.2 The volumes of excavation to be paid for chimney and pyramid type foundation will be the volume as per foundation drawings inclusive of 150 mm on all side to allow the workers to work in-side the pit.

- 13.3 The volumes of excavation for submerged foundation will be paid on the basis of volumes actually excavated or worked out from the approved drawings whichever is lower.
- 13.4 Whenever the necessity arises for leveling of soil, building revetment for dry stone or random stone revetment or concrete revetment or brick masonry with cement, these works shall be paid to successful tenderer at the revetment rates.
- 13.5 In addition to all above, whenever shuttering or shoring is necessary the same will be done at no extra cost to the NIGAM.
- 13.6 If for shallow foundation, the stub is required to cut, proper record shall be maintained for such locations in terms of cut lengths. The cutting of stub shall be arranged by the contractor at no extra cost to the NIGAM.

14 CONCRETE:

- 14.1 The cement required shall be arranged by the contractor. The quantity of cement shall be worked out based on the finally approved foundation drawings and subject to the maximum as per the guaranteed volumes.
- 14.2 The cement consumption for different types of concrete shall be considered as follows:
 - For 1:1.5:3 mix. - 8.2 Bags. per Cu. meter
 - For 1:2:4 mix. - 6.5 Bags. per Cu. meter.
 - For 1:3:6 mix. - 4.5 Bags, per Cu. meter.
 - For 1:4:8 mix. - 3.5 Bags, per Cu. meter.
- 14.3 The sand shall be of the best quality containing hard silicious materials, clean and of sharp angular grit type and free from earth or organic matter or salts and to the satisfaction of the Engineer-in-Charge. No saltish or brackish water shall be used for concreting.
- 14.4 The coarse aggregate shall be of the best quality to the satisfaction of the Engineer-in-charge and broken to maximum size of 20mm for concrete section. It should also be free from grit and dirt.
- 14.5 The mixture of concrete to be used shall be such as to produce a sound, compact and water proof concrete and shall not be weaker than 1:2:4 ratio with 20mm stone material for chimney and 20mm or 40 mm for pyramid. Unit rates may be quoted for concrete of 1:3:6 and 1:4:8 ratio. The concrete shall be machine mixed only & shall be as stiff as the requirements of placing the concrete in the form of moulds with ease and degree to which concrete resist segregation will permit. Hence; the quantity of water used should not be too much.
- 14.6 The dimensional drawing of form boxes shall be got approved from RVPN. Proper form or moulds adequately braced to retain proper shape while concreting, should be used for chimney or pyramid and slab portions. Form-boxes should be water tight so as not to allow cement cream to come out leaving only sand and gully to form honey combs in concrete. Form boxes should be made out of M.S. Sheet having adequate thickness for handling and should be cleaned and oiled before using for concreting.
- 14.7 All wet locations must be kept completely dewatered both during the placing of concrete and for 24hrs. after completion. There should be no disturbance of concrete by water during this period. All arrangement for dewatering shall be done by the contractor as included in the scope of erection.

- 14.8 Form boxes should not be removed before 24 hrs. after concreting. Concrete surfaces where require, should be set right with rich cement and mortar immediately after removal of the forms.
- 14.9 After 24 hours of pouring, the concrete should be cured by keeping it continuously wet for 14 days. After 48 hours of pouring, the pit may be back filled with excavated selected earth (which is free from grass, dung, wooden waste, postures & fodder woods, shrubs, thorn etc.) sprinkled with necessary amount of water and well compressed & consolidated in layers not exceeding 150mm. Thereafter the exposed top and the fill shall be kept wet for the remainder of the prescribed curing. Extra ordinary care should be taken during back-filling. The Contractor and NIGAM's Engineers at site shall ensure that back-filling is done in the manner referred to above. So that back-filled earth becomes homogenous with surrounding parent soil with the passage of the time.
- 14.10 The Engineers of the contracting parties shall record the day/date of back-filling and jointly sign in the register for its correctness.
- 14.11 Adequate quantity of form boxes for all types for chimney and pyramids shall be prepared by the contractor as per approved foundation design, drawing at his cost.
- 14.12 Payments for the quantity of excavation and concreting for each type of tower shall be made on pro-rata basis of actual work done subject to the maximum of guaranteed volumes as per the approved drawings to be furnished by the NIGAM.
- 14.13 The cement & reinforcement steel shall be procured by the Contractor. No price variation shall be allowed on cement & steel so supplied.

15. ERECTION OF TOWERS:

- 15.1 Standard tangent towers with reduced spans shall normally be used for all important road crossings.

15.2 CLEARENCE OF EHV LINES:

S.No.	Authorities	Minimum EHV Line Clearance i.e. from lowest portion of the conductor from the Highest Track level at crossing
1.	NHAI/MAIN ROAD CROSSING	400 KV : 14.00m 220 KV : 12.52m 132 KV : 11.60m
2.	Railways(including DFCC Works)	Minimum height above rail level of the lowest portion of any conductor of a crossing, including guard wire, under condition of maximum sag 220 kV : 18.46 Meters 132 kV : 17.56 Meters While spotting towers across railway crossing spans a suitable additional clearance on above (preferably 3 Meters) be added to accommodate for desired sag in shorter spans and use of double tension hardware so that the required minimum height achieved.

Note:

- The minimum clearance as mentioned above are as per existing/ prevailing requirements. If it is changed by concerned authority or by statutory requirement the same shall be amended and adhered accordingly.

2. These are minimum prescribed guideline for clearance requirements, however, if concerned authority requires more clearance from minimum prescribed as per specific site conditions/ requirements the same shall be agreed mutually and accordingly technical proposals and estimated be prepared / verified.

TOWER AND OTHER CROSSING REQUIREMENT/ GUIDELINES:

S.No.	Authorities	General Crossing Requirements/Guidelines
1.	NHAI	<p>Terminal Towers: Angle Towers(For all new crossings and for existing crossings, if modification is required for increasing clearance of EHV Lines)</p> <p>Insulator string of Crossing Span: Double Tension</p> <p>Crossing Angle : Generally right angle to road</p> <p>Max Span across track between terminal tower: normally not exceeding 250 meters</p> <p>One of the towers of the crossing span shall be located near the road to obtain additional clearance.</p>
2.	Railways(including DFCC Works)	<p>Terminal Towers: Large Angle /Dead End</p> <p>Insulator String of Crossing Span : Double Tension with one additional disc insulator</p> <p>Crossing Angle : Generally right angle to track</p> <p>Max Span across track between terminal tower: Normally not exceeding 300 meters or to 80% of the normal span for which the structures are designed whichever is less.</p> <p>Falling Distance:</p> <p>The minimum distance of the structure (supporting the crossing span) from the center of the nearest railway track shall be equal to the height of the structure in meters above normal ground level plus 6 meter.</p>

The approval for crossing the railway track shall be obtained by the NIGAM from the Railway Authority however six copies of profile and plan tower and foundation design and drawings required for the approval from the Railway Authority shall be supplied by the Contractor to the NIGAM.

- 15.3 The Super-structure of towers should be erected on foundation after 14 days of concreting. However, the method adopted for erection of tower is left to the discretion of the contractor subject to the condition that he takes responsibility for any damage to materials. No tower member should get strained or bent during erection. The towers must be truly vertical after erection and no straining would be allowed to bring it in alignment. Maximum tolerance in verticality that will be permitted is one mm per 360mm of tower height. All bolts and nuts shall be made fully tight and finally the bolt threads shall be centre punched to avoid nuts becoming loose. The bolt head shall be on outside faces & nuts & washers on inside faces of the tower.

Punching of bolts shall be made by chamfering the threads with centre punch at least at three places equally spaced on contact surface of bolts and nuts.

- 15.4 Tower erection shall include erection of all accessories like danger plate, number plate, phase plate, C.I. plate, Anti-climbing devices and fittings including attachments for step bolts, ladders, platforms, 'U' bolts, D-shackles, hangers strain plate, etc. and punching of bolts and nuts so that towers are complete in all respects.
- 15.6 Suitable tower extension shall be erected to get desired ground clearance whenever required which have been determined at the time of final survey.
- 15.7 To avoid pilferage of bolts and nuts and tower members, the bolts of the two bottom panels (say upto 10 meters) shall be tack welded upto bottom cross arm/beam level at three places on the nuts diametrically. The zinc rich paint shall be applied immediately following the tack welding at no extra cost i.e. the rate of erection of tower/ extension shall include the charges for the above works.

16 GROUNDING :

16.1 It is necessary that in no case tower footing resistance should be more than 10 ohms. during dry weather.

16.2 PIPE TYPE EARTHINGS :

16.2.1 At locations where footing resistance does not exceeds 10 ohms, the pipe type earthing as per method shown under Drawing (enclosed) would be followed. The contractor will have to supply all materials required for grounding including salt, fine broken coke/charcoal. The earthing is to be done by using augur & making a bore hole for insertion of pipe away from the tower leg excavation line.

16.2.2 If it is observed that the earthing arrangement is done within leg excavation pit, the proportionate deductions will be made from the bills.

16.3 COUNTERPOISE EARTHING :

In places of high resistivity soil conditions, counterpoise earthing shall be adopted as shown under drawing (enclosed) to bring down the tower footing resistance below 10 ohms. The counterpoise earthing shall be buried 500mm below ground level and for this purpose some space should be left out in chimney coping portion at the time of stub-setting. Coping should be completed after installation of counterpoise earthing. In case of rocky terrain the C.P. earthing have to be embedded at a depth of 100 mm.

16.4 The galvanized stranded wire shall be of the size 7/3.15 mm

16.5 The record of footing resistances shall be maintained in consultation with Engineer-in-charge before and after providing of suitable earthing.

16.6 INSULATOR HOISTING :

Suspension insulator strings shall be used on all tangent type towers with deviation upto 2 deg and tension insulator strings on all small, medium, large angle and dead end type towers on all lines.

Technical particulars of conductor and insulator strings are indicated in the respective Appendix.

Insulators strings shall be assembled on ground. These shall be cleaned and examined for hair cracks, chips or defective glazing(not exceeding half centimeter square) and than hoisted by careful handling. The work will include fittings of all hardwares and fittings in their proper places and order.

17. STRINGING OF CONDUCTOR

Before commencing of stringing work, contractor must obtain approval of sag tension charts (these shall have to be supplied by the Contractor) showing initial and final sags and tensions for various temperature and spans. The details of spans, temperature range etc, will be furnished to the successful tenderer after the check survey completed. The sag NIGAM, if used shall be adjusted to suit to the sag indicated against actual temperature for an individual span. The thermometer shall be provided at the conductor point during the stringing work.

The contractor shall be responsible and will take care of proper handling of drums from stores to site. Sufficient numbers of aluminum snatch blocks shall be used for paying out the ACSR Conductors. Necessary precautions shall be taken to avoid conductor rubbing on the ground by providing adequate ground rollers on supports. Additional rollers shall also be provided to cross thorny hedges, forcing and other obstructions to avoid scratching of conductor. The conductor shall be made to sag correctly as per stringing charts before they are finally transferred to the hardware for conductors. No joint should be made at less than 30 meters from the tower end and no joint shall be permitted in Railway, River, Road and other important crossing spans. There shall not be more than one joint in a span of each conductor. All conductors shall be stressed to their maximum working load at the time of stringing, as per approved stringing charts. The minimum clearance between the lowest point of conductor and ground shall not be less than 6100mm. All compression joints should be carefully made and record of initial and final lengths of the joints jointly signed by Contractor's and NIGAM's Representative should be maintained. Dynomo-meters shall be used in tensioning the conductors, check for sag should also be made at intervals when conductors are drawn up. Over stressing, causing damage to towers should be avoided. Care should be exercised not to over tension the conductor. An extra sag of 50mm be allowed at all the important tension locations like Railway/River crossings.

After being pulled the conductor shall not be allowed to hang in the stringing sheaves for more than 72 hours, before being pulled to the specified sag. During the time the conductor is on, the stringing sheaves before sagging-in, it shall be ensured that the conductor is not damaged due to wind, vibration, vehicles or other causes, So affording should be used to cross the important roads and Railway for minimum interruption to traffic.

The conductor shall be pulled upto desired sag and left in serial stringing sheaves for at least one hour after which the sag shall be re-checked and adjusted, if necessary, before clipping in and transferring the conductors from the serial stringing sheaves to the suspension clamp.

Conductors shall be clamped within 24 hours of sagging in. The sag will be checked in the larger spans of the section in case of sections upto eight spans and in one intermediate larger span also for section with more than eight spans..

The stringing sheaves, when suspended on the transmission structure for sagging, shall be so adjusted that the conductor will be on the sheaves at the same height as the suspension clamp to which it is secured.

All the line conductors shall be terminated at sub-station structures whose details shall be furnished by the NIGAM at the appropriate time. The conductor shall fix strain insulators on the sub-station structures

Armour rods and vibration dampers shall be fitted at each suspension towers before final clamping of conductor with insulator strings. Vibration dampers are to be fixed using aluminum tape with each clamping bolt and incorrect vertical position in relation to conductor.

Compression type joints are to be used for joining of conductors. Each part connected with joints shall be perfectly cleaned by wire brush and properly greased before final compression. All the joints of conductor shall be made in the best workmanship manner and shall be perfectly straights and having maximum possible strength V.D. shall be fitted on each location on G.W.also.

Stringing work includes hoisting the insulators fixing hardware, fitting armour rods and vibration dampers, making joints, repair sleeves, etc. All stringing tools special or otherwise should be arranged by the conductor at their cost.

Proper guys shall be provided to counter balance the paying out tension of conductor at the tension locations, to avoid damage to towers and/or accidents.

18. TESTING & COMMISSIONING:

18.1 Pre commissioning tests:

On completion of erection of the transmission line and before charging, each item shall be thoroughly cleaned and then inspected jointly by the purchaser or his duly authorised representative and the contractor for correctness and completeness of installation and acceptability for charging leading to initial pre-commissioning.

The contractors commissioning engineers specifically identified as far as possible shall be responsible for carrying out all the pre-commissioning checks. On completion of inspection, checking and after the pre-commissioning tests are satisfactorily over, the complete line shall be ready for charging.

During the pre-commissioning checks, the operation shall be under the supervision of the contractor, but the schedule of operations shall be agreed to by the purchaser and the contractor. During the tests, the safety of the line materials also etc. is the responsibility of the contractor. During the pre-commissioning, commissioning and performance guarantee tests, the operation will be under the supervision of the contractor if the tests are being carried out by him. In case the tests are being carried out by a third party, the operations will be under the control of the purchaser. In both cases, all aspects of the tests shall be agreed to by the purchaser and the contractor and the safety of the equipment shall be the responsibility of the contractor.

18.2 After the erection is completed in all respects, the line should be the roughly petrolled and checked for continuity and clearances. The line should be meggered to check its insulation level. Afterwards a line clear should be given to the Engineer-in-charge that the line is clear and free of man and materials and is fit to be charged. If on charging the line is found not to hold, the contractor should arrange to petrol the line and find out the causes for the tripping and rectify the defect at no extra cost to the NIGAM

The Contractor shall ensure that at the end of each sub-activity the surplus material is immediately removed from the work-site to avoid loss and injury to the public.

19. WASTAGE:

Since the erection & commissioning of the lines included in this specification are on Supply & ETC basis as such no wastage is allowed for any material.

However, for OPGW (to be supplied by successful bidder) and ACSR ZEBRA & ACSR PANTHER conductor (to be supplied by successful bidder) an extra allowance @ **0.3%** shall be allowed towards sag and jumpering which shall be unaccountable. The empty drums of conductor and OPGW shall be retained by the contractor. No cost on this account will be deducted in cases where conductor is supplied by nigam . ~~The cost of Rs.300.00 per empty drum of conductor and Rs.100.00 per empty drum of OPGW will be deducted from the bills payable to the contractor.~~

SECTION - IV

GTP DRAWINGS &

TECHNICAL PARAMETERS FOR

TRANSMISSION LINE EQUIPMENTS

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APPENDIX-I(A)**TECHNICAL PARTICULARS FOR 132 kV TRANSMISSION LINES**

S.NO.	DESCRIPTION			
A	GENERAL			
1	Line voltage	132kV		
2	No. of circuits	One / Two		
3	Normal span	335 M		
4	Wind span	335 M		
5	Weight span	Tangent tower	Angle tower	
	Maximum (downwards)	1.5x335=503 M	1.5x335=503 M	
	Minimum (downwards)	0.65x335=218 M		
	Minimum (upwards)		0.65x335=218 M	
B	CONDUCTOR { IS:398 (Part-II) 1996 }			
1	Material	200Sq.mm. Nominal Aluminum area ACSR galvanized steel reinforcement		
2	Size & stranding	Al 30/3.00 + St – 7/3.00 mm Code 'Panther'		
3	Total sectional area	2.616 Sq.cm.		
4	Ultimate strength	9144 Kgs. (89.67 KN)		
5	Overall diameter	2.10 cm.		
6	Weight	974 Kg/Km		
C	INSULATOR			
1	Size of disc 25.5 cm	25.5 cm dia spaced at 14.6 cm.		
2	Type of disc	Conventional ball & socket type		
3	No. of disc			
(a)	Suspension string	9		
(b)	Tension string	10		
4	Insulator string	Length without ha	Weight Kg. (App.)	Electro Mechanical Strength (Kg.)
(a)	Single Suspension	1676	60	7000
(b)	Double Suspension	1909	125	7000
(c)	Single Tension	2230	100	12000
(d)	Double Tension	2575	200	12000

TECHNICAL PARTICULARS FOR 220 kV TRANSMISSION LINES

S.NO.	DECRPTION			
A	GENERAL			
1	Line voltage	220kV		
2	No. of circuits	One / Two		
3	Normal span	350 M		
4	Wind span	350 M		
5	Weight span	Tangent tower	Angle tower	
	Maximum (downwards)	1.5x350=525 M	1.5x350=525 M	
	Minimum (downwards)	0.65x350=228 M		
	Minimum (upwards)		0.65x350=228 M	
B	CONDUCTOR { IS:398 (Part-II) 1996 }			
1	Material	400Sq.mm. Nominal Aluminum area ACSR galvanized steel reinforcement		
2	Size & stranding	Al 54/3.18 + St – 7/3.18 mm Code 'Zebra'		
3	Total sectional area	484.5 Sq.mm.		
4	Ultimate strength	13290 Kgs. (130.32 KN)		
5	Overall diameter	28.62 mm.		
6	Weight	1621 Kg/Km		
C	INSULATOR			
1	Size of disc 25.5 cm	25.5 cm dia spaced at 14.6 cm.		
2	Type of disc	Conventional ball & socket type		
3	No. of disc			
(a)	Suspension string	13		
(b)	Tension string	14		
4	Insulator string	Length without hanger mm	Weight Kg. (App.)	Electro Mechanical Strength (Kg.)
(a)	Single Suspension	2256	80	7000
(b)	Double Suspension	2515	175	7000
(c)	Single Tension	2940	130	12000
(d)	Double Tension	3215	275	12000

TECHNICAL PARTICULARS FOR 220 kV TRANSMISSION LINES SPECIAL STRUCTURE

S.NO.	DECEPTION			
A	GENERAL			
1	Line voltage	220kV		
2	No. of circuits	Two		
3	Normal span	510 M for river crossing & 200 M for line crossing		
4	Wind span	510 M for river crossing & 200 M for line crossing		
5	Weight span (acting downw	1.5 times the nominal span		
B	CONDUCTOR { IS:398 (Part-II) 1996 }			
1	Material	400Sq.mm. Nominal Aluminium area ACSR galvanized steel reinforcement		
2	Size & stranding	Al 54/3.18 + St – 7/3.18 mm Code 'Zebra'		
3	Total sectional area	484.5 Sq.mm.		
4	Ultimate strength	13290 Kgs. (130.32 KN)		
5	Overall diameter	28.62 mm.		
6	Weight	1621 Kg/Km		
C	INSULATOR			
1	Size of disc 25.5 cm	25.5 cm dia spaced at 14.6 cm.		
2	Type of disc	Conventional ball & socket type		
3	No. of disc			
(a)	Suspension string	13		
(b)	Tension string	14		
4	Insulator string	Length without hanger mm	Weight Kg. (App.)	Electro Mechanical Strength (Kg.)
(a)	Double Suspension	2515	175	7000
(b)	Double Tension	3215	275	12000

NOTE:-

1. Normal height of the special structure should be designed in accordance with the river crossing.
2. Ground level is to be considered as maximum flood level in case of river crossing.
3. Since, most of the rivers are of such nature in which water flows only for a limited period and during dry period, the river bed is used by the pedestrians to cross it, in such situation, it will require a ground clearance of 7 meters.
4. During dry period, the depth of the river may be taken as 2 meters below the ground level.
5. Tower is to be designed for 2 Deg. line deviation however, arrangements are to be made at cross-arm **trips** for attaching double tension insulator strings also.
6. The height of the 220kV D/C lines to be crossed by these structures is to be taken as 34 meters.
7. Suitable extension of 4.5, 9 and 18 meters are to be provided with these special structures so as to achieve the requirement of line crossing.
8. Since, there is a possibility of stringing of only one of these, double circuit structures at initial stage, these structures should be designed with S/C strung conditions.

DETAILS OF CLEARANCES

1	Line Voltage	132kV	220kV
2	No. of circuits	One/Two	One/Two
3	Minimum Electrical Clearance between Conductors.		
(i)	Vertical	3900	4900
(ii)	Horizontal	6600	8400
4	Clearance:		
(a)	Single suspension string with angle of swing:-		
(i)	NIT	1530mm	2130mm
(ii)	15 Deg.	1530mm	1980mm
(iii)	30 Deg.	1370mm	1830mm
(iv)	45 Deg.	1220mm	1675mm
(v)	60 Deg.	1070mm	
(b)	Double suspension string –angle of swing	1530mm	2130mm
(c)	Tension string (Single /double-With no swing	1530mm	2130mm
(d)	Jumper with angle of swing:		
(i)	NIT	1530mm	2130mm
(ii)	10 Deg.	1530mm	2130mm
(iii)	20 Deg.	1070mm	1675mm
(iv)	30 Deg.	1070mm	
5	Minimum Ground Clearance	6.1 M	7.0 M
6	Minimum vertical Mid Span clearance between earth wire and the nearest power conductor	6.1 M	8.5 M

APPENDIX-III**FOUNDATION PARTICULARS****LINE VOLTAGE : 220KV AND 132KV****NO. OF CIRCUIT : ONE/TWO**

S.NO.	DESCRIPTION	DETAILS
1	Type of soil(s) clay	(i) Dry (ii) Wet (iii) Partially submerged (iv) Fully submerged
2	Ultimate bearing pressure (Kg./Sq.m.)	(i) Dry - 30000 (ii) Wet – 10900
3	Angle of internal friction of soil (Degrees)	(i) Dry - 25 (ii) Wet – 10
4	Weight of earth (Kg./Cu.m.)	(i) Dry - 1440 (ii) Wet – 940
5	Weight of concrete (Kg./Cu.m.)	(i) Dry - 2200 (ii) Wet – 1200
6	Concrete Mixture	
(i)	Pad	M10 – 1:3:6 (Size of the aggregate 40.0m.m.)
(ii)	Pyramid or stepped part	M15 – 1:2:4 (Size of the aggregate 20.0m.m.)
(iii)	Chimney	M15 – 1:2:4 (Size of the aggregate 20.0m.m.)
7	Minimum thickness of concrete over stub	100 mm
8	Minimum chimney size	300 mm square
9	Length of stub concrete	1500.00 mm
10	Distance between lower edge of stub angle and pad of base concrete	100 – 150 mm
10A	Distance above ground level of joint of tower stub and super structure	600.00mm Out of this 300mm of stub member above G.L. (Shall be encased in concrete)

NOTE:- The magnitude of limit loads for foundation shall be taken 10% higher than those for the corresponding towers.

Appendix-IV(1)

**GUARANTEED TECHNICAL & OTHER PARTICULARS OF 70KN & 120KN DISC INSULATORS/
132KV & 220KV, SUSPENSION(70KN) & TENSION (120KN) PORCELAIN LONGROD
INSULATORS**

S.No.	DESCRIPTION	DETAILS		
		For 70 KN		For 120 KN
1	Type	Conventional Ball & Socket, Disc Insulators "B"/ Porcelain longrodinsulators"A"		
2	Specification to which the insulator shall confirm	IS:731/1971, latest amendments, IEC-383, IS:3188/1988, IS:2486(Pt-I)/1993(Second Rev.), IS:2486(Pt-II)/1989 (Second Rev.) & IS:2486 (Pt-III) / 1974, latest edition of IEC:433/1980 & IEC:575/1977		
3	Dimension			
(a)	Diameter	255 mm (disc)		
(b)	Spacing	145 mm (disc)		
(c)	Tolerance	AS per relevant ISS		
(d)	Colour	Brown		
(e)	Surface	Glazed		
(f)	Description (Material & surface treatment)			
(i)	Socket cap	MCI / SGI		
(ii)	"W/R" Clip	Phosphor Bronze / Stainless steel		
(iii)	Cushion			
(iv)	Ball Pin	Drop forged steel		
4	Creepage distance			
(a)	For 70KN Disc	280 mm (Min.)		
(b)	For 120KN Disc	290 mm (Min.)		
(c)	For 132kV string for moderately polluted atmosphere (total)/porcelain longrod insulator	2250 mm (Min.)		
(d)	For 220kV string for moderately polluted atmosphere (total)/ porcelain longrod insulator	3800 mm (Min.)		
5	Ball Dia	16 mm		20 mm
	Visible discharge test (disc)	9 kV (RMS)		
	Wet power frequency withstand test(disc)	35 kV (RMS)		
	Impulse voltage withstand test(disc)	75 kV (Peak)		
6	Electromechanical strength	70 KN		120 KN
7	All electrical & mechanical values of string	Confirming to highest system voltage 245kV/145kV in Table-1A of IS:731/1971 (with latest amendments)		
8	No. of Disc for single tension string for normal tension location	-----	-----	10 Nos.- For 132kV system & 14 Nos.- For 220kV system
9	No. of Disc for double tension string for special tension location	-----	-----	2X10 Nos.- For 132kV system & 2X14 Nos.- For 220kV system
10	No. of Disc for single suspension string for normal suspension location	09 Nos.- For 132kV system	13 Nos.- For 220kV system	-----
11	No. of Disc for double suspension string for normal suspension location	2X9 Nos.- For 132kV system	2X13 Nos.- For 220kV system	-----
12	Power System	132kV 3 Phase, 50 Cycles		220kV 3 Phase, 50 Cycles

		effectively earthed	effectively earthed
(a)	Highest system voltage	145kV (RMS)	220kV (RMS)
(b)	Visible discharge test (Power frequency voltage)	105 kV (RMS)	154kV (RMS)
(c)	Wet power frequency withstand test	230kV (RMS)	395kV (RMS)
(d)	Impulse voltage withstand test	550kV (Peak)	900kV (Peak)
(e)	Power Frequency	1.3 times the actual dry flash over voltage of the unit	
(f)	Max. temperature of insulator carrying current and exposed to Sun	75 Deg.C.	

GUARANTEED TECHNICAL & OTHER PARTICULARS OF SINGLE SUSPENSION, DOUBLE SUSPENSION, SINGLE TENSION & DOUBLE TENSION HARDWARE FITTINGS SUITABLE FOR ACSR "ZEBRA" & ACSR "PANTHER" CONDUCTOR.

S.NO.	DESCRIPTION	SINGLE& DOUBLE SUSPENSION HARDWARE SINGLE & DOUBLE TENSION HARDWARE	
1	Size & designation of Ball and Socket with Standard spec. to which it conforms	Suspension H/W : 16mm Tension H/W : 20mm As per IS:2486/ P- I to IV, latest amendment	
2	Hardware components description		
	Socket Clevis / Tongue / Eye	FS	
	Ball Clevis / Eye	FS	
	Clevis Clevis / Eye	FS	
	Chain Link	FS	
	Yoke Plate	MS	
	Arcing Horn	MS	
	Security Clip	SS	
	Ball Hook/ U-shackle / U-clevis	FS	
	Fasteners		
	Plain washers	MS	
	Split pins	BRASS / SS	
	Nuts & Bolts	MS / FS	
	Spring washers	SS	
	Cotter pins	FS / MS	
3	Standard Specifications to which the material conforms to	IS:2486/ Part-I to IV	
4	Standard Specifications to which the galvanizing conforms to	IS:2633 : Hot dip Galv. IS: 1577: Electro Galv.	
5	Clamps		
(i)	Components description	Suspension clamps	Tension clamps
(a)	Clamp body	H.S. Al. Alloy /Alu. Alloy Gt.4600 of IS:617 latest amendments	EC grade Al. (Min. purity 99.5%)
(b)	Keeper Plate	H.S. Al. Alloy	
(c)	Steel sleeve	FS	
(ii)	Slip strength	8 to 15% of conductor breaking load	95% of conductor breaking load
(iii)	Breaking strength		
	ACSR ZEBRA	7000 Kgs	13289 Kgs
	ACSR PANTHER	4500 Kgs	9144 Kgs.
(iv)	Electrical resistance	75% of the resistance of Conductor	
6	Complete String		
(i)	Mechanical failing load	Suspension clamps	Tension clamps
	ACSR ZEBRA	7000 Kgs	13289 Kgs
	ACSR PANTHER	4500 Kgs	9144 Kgs.

**GUARANTEED TECHNICAL & OTHER PARTICULARS FOR ARMOUR ROD SUITABLE FOR
ACSR "ZEBRA" & ACSR "PANTHER" CONDUCTOR.**

S.NO.	DESCRIPTION	ACSR ZEBRA	ACSR PANTHER
1	Type	Pre – formed	
2	Suitable for (Conductor size)	28.62 mm	21 mm
3	No. of rods per set	12	11
4	Breaking strength of single rod	Min. 35 Kg per sq.mm.	
5	Length of each rod	2540 mm	1930 mm
6	Diameter of each rod	7.87mm, Tolerance – 0.0 to -0.1mm	6.35mm Tolerance – 0 to -0.1mm
7	Tolerance in dimensions	0 to (-)51 mm	
8 (a)	Raw material used	Al. Alloy	
8 (b)	Percentage purity of raw material used	99% purity	
9	Standard to which material will be manufactured and tested	IS:2121 / Part- I / 1981	
10	Conductivity	Min. 39% of IACS	
11	Lay of Helix	Right Hand	
12	Slip strength	25% of UTS of conductor	

**GUARANTEED TECHNICAL & OTHER PARTICULARS FOR MID SPAN COMPRESSION JOINT
SUITABLE FOR ACSR "ZEBRA" & ACSR "PANTHER" CONDUCTOR.**

S.NO.	DESCRIPTION	ACSR ZEBRA	ACSR PANTHER
1	Type	Compression	
2	Suitable for (Conductor size)	28.62 mm	21 mm
3	Outside diameter of sleeves		
(a)	Before compression		
(i)	Aluminium	48 mm	38mm
(ii)	Steel	20.8 mm	18mm
(b)	After compression		
(i)	Aluminium	40/46 mm	32/37 mm
(ii)	Steel	17.5/20.2 mm	15.1/17.4 mm
4	Guaranteed breaking load strength of the mid span joint as percentage of ultimate tensile strength of conductor	95%	
5	Conductivity of the compression joint expressed as percentage of the conductivity of the conductor	100%	
6	Guaranteed slip strength of the mid span joints expressed as percentage of ultimate tensile strength of conductor	95%	
7	Resistance as percentage of measured resistance of equivalent length of conductor	Less than 75%	
8	Standard specification to which the material will be manufactured and tested	IS:2121/P-II/1981 with latest amendments	

**GUARANTEED TECHNICAL & OTHER PARTICULARS FOR REPAIR SLEEVES
SUITABLE FOR ACSR "ZEBRA" & ACSR "PANTHER" CONDUCTOR.**

S.NO.	DESCRIPTION	ACSR ZEBRA	ACSR PANTHER
1	Type	Compression	
2	Suitable for (Conductor size)	28.62 mm	21 mm
3	Outside diameter of sleeves		
(a)	Before compression		
(i)	Aluminium	48 mm	38mm
(b)	After compression		
(i)	Aluminium	40/46 mm	32/37 mm
4	Standard specification, to which the material will be manufactured and tested	IS:2121, P-II, 1981	

**GUARANTEED TECHNICAL & OTHER PARTICULARS FOR VIBRATION
DAMPERS SUITABLE FOR ACSR "ZEBRA" & ACSR "PANTHER" CONDUCTOR.**

S.NO.	DESCRIPTION	ACSR ZEBRA	ACSR PANTHER
1	Type	4 R	
2	Messenger Cable		
(a)	Total no. of strands	19	
(b)	Strength of the steel used	135 Kg/Sq.mm.	
(c)	Shield or not	Shield	
3	Magnetic power loss value of damper at current rating value of conductor	Less than 1 watt for 500 A	-----
4	Material, its type and composition for various dampers components		
(a)	Clamps	Al. Alloy	
(b)	Damper mass	Cast iron	
(c)	Messenger cable	High strength steel	
(d)	Bolts & Nuts	MS	
5	Mass Pull off load	500 Kg. (Min.)	
6	Acceptance curve for damping efficiency	IS:9708 / 1993	

GUARANTEED TECHNICAL & OTHER PARTICULARS FOR ELECTROGALVANISED SPRING WASHERS.

S.NO.	DESCRIPTION	DETAILS
1	Specification & standards for	
(a)	Spring washers	As per IS : 3063 / 1994
(b)	Galvanising	As per IS:1573/1986, Grade-4 with latest amendments
2	Size	M 16 – B
3	Tolerance	As per IS : 3063 / 1994
4	Raw material	
(a)	Grade	Service Grade 3
(b)	Type of Steel used	Carbon steel Grade 3 as per IS:4072/1975 with latest amendments
5	Chemical Composition (%)	IS:4072/1975 service grade 3/ Designation 70 C 6
(a)	Carbon % Max.	0.65 to 0.75 %
(b)	Phosphorous % max.	0.05 %
(c)	Sulphur % Max.	0.05 %
(d)	Silicon % max.	0.10 to 0.35 %
(e)	Manganese % Max.	0.50 to 0.80 %
6	Standard to which spring washer shall conform	
(i)	Sampling procedure confirming to ISS	As per IS:6821/1973 for spring washers & As per IS:1573/1986 for galvanizing
(ii)	Inspection/checking/testing as per ISS	As per IS:3063/1994 & IS:4072/1996
(iii)	Dimensions	
(a)	Internal diameter	16.2 + 0.8 mm
(b)	Wire section	(5 +/- 0.2) x (3.5 +/- 0.2)
(c)	Free height	7.00mm Min. & 8.30mm Max.
(iv)	Hardness test	43.6 to 50 HRC
(v)	Twist test	No sign of fracture upto 90 deg.
(vi)	Permanent set test	As per IS:3063/1994
(vii)	Galvanising	25 Microns - Min. local thickness & 38 Microns – Min. average thickness
(viii)	Standard specn. according to which quality and process of galvanizing shall confirm	As per IS:1573/1986, Service Grade – 4
7	Weight of spring washers	0.891MT per Lac Nos. as per IS:3063/1994

GUARANTEED TECHNICAL & OTHER PARTICULARS FOR G.I. BOLTS & NUTS.

S.NO.	DESCRIPTION	DETAILS
1	Specification & standards for Galvanised Bolts – Nuts	As per IS:12427/2001, IS:1363(Pt-III)/1992, IS:1367 (Pt-2/2002,3/2002&6/1994) & IS:14394/1996
2	Property class	
(a)	For Bolt	“5.6” (as per IS:12427/2001) & properties as specified in IS:1367 (Part-3)/2002
(b)	For Nut	“5” (as per IS:12427/2001) & properties as specified in IS:1367 (Part-6)/1994
3	Tolerance	As per IS:1367 (Part-2)/2002
4	Raw material	
(a)	Grade	“C” as specified in IS:1367 (Part-II)/2002
(b)	Type of Steel used	Low or medium Carbon steel
(c)	Dimension	Nominal dia - 16 mm
(d)	Length of Bolt	35,40,45,50,55,60,65,70,75 & 85(as per IS:12427/2001)
(e)	Length of Nut	15 mm (as per IS:1363 (Part-3)/1992
5	Chemical Composition (%)	
(i)	For Hexagonal Bolts:	
(a)	Carbon % Max.	0.15 to 0.55 %
(b)	Phosphorous % max.	0.05 %
(c)	Sulphur % Max.	0.06 %
(ii)	For Hexagonal Nuts:	
(a)	Carbon % Max.	0.50 %
(b)	Phosphorous % max.	0.06 %
(c)	Sulphur % Max.	0.15 %
6	Mechanical properties	
(i)	For Hexagonal Bolts:	
(a)	Tensile strength (N/Sq.mm.)	500 (Min.)
(b)	Yield Stress (N/Sq.mm.)	300 (Min.)
(c)	Stress under proof load (N/Sq.mm.)	280 (Min.)
(d)	Brinell Hardness HB	147 (Min.)
(e)	Rockwell Hardness HRB	79 (Min.)
(f)	Vickers Hardness HV	155 (Min.)
(g)	Elongation after fracture % Min.	20%
(h)	Strength under wedge loading	500 (Min.) N/Sq.mm.
(i)	Head Soundness	No fracture
(j)	Impact strength test (J)	25 (Min.)
(ii)	For Hexagonal Nuts:	
(a)	Proof stress (N/Sq.mm.)	490 (Max.)
(b)	Vickers Hardness HV- (Min.-Max.)	130-302
7	Galvanising	
	(Hot dip mass and eqt. Thickness of coating)	
(a)	Min. average coating	
(i)	Mass g/Sq.M	375
(ii)	Thickness micrometer	54
(b)	Minimum individual coating	
(i)	Mass g/Sq.M	300
(ii)	Thickness micrometer	43
8	Sampling procedure	
(a)	For G.I. Bolt-Nuts	As per IS:1367 (Part-17)/1996
(b)	Galvanising	IS:1367 Pt-XIII – 1983
9	Whether the material bear ISI certification mark	YES

**GUARANTEED TECHNICAL & OTHER PARTICULARS FOR G.I. STEP BOLTS WITH TWO NUTS
& TWO PLAIN WASHERS.**

S.NO.	DESCRIPTION	DETAILS
1	Specification & standards for Galvanised Bolts – Nuts	As per IS:10238/2001 & IS:1363(Pt-III)/1984 IS:1367(Pt-II/2002), (Pt-III/2002),(Pt-VI/1994), (Pt-XIII/1988) and IS:12427/2001 With latest amendments
2	Property class	
(a)	For Bolt	4.6 (IS:1367 Pt-III/2002)
(b)	For Nut	5 (IS:1367 Pt-VI/1994)
3	Tolerance for Step Bolt-Nuts	As per IS:10238/2001, IS:2016/1967 & IS:1367 (Part-2)/2002
4	Raw material	
(a)	Grade	C
(b)	Type of Steel used	Low or medium Carbon steel
(c)	Dimension	M 16
(d)	Length of Bolt	175mm (as per IS:10238/2001) Plain washer (as per IS:2016/1967)
5	Chemical Composition (%)	
(i)	For Step Bolts:	
(a)	Carbon % Max.	0.55 %
(b)	Phosphorous % max.	0.05 %
(c)	Sulphur % Max.	0.06 %
(ii)	For Nuts:	
(a)	Carbon % Max.	0.50 %
(b)	Phosphorous % max.	0.06 %
(c)	Sulphur % Max.	0.15 %
6	Mechanical properties	
(i)	For Step Bolts:	
(a)	Tensile strength (N/Sq.mm.)	400 (Min.)
(b)	Yield Stress (N/Sq.mm.)	240 (Min.)
(c)	Stress under proof load (N/Sq.mm.)	225 (Min.)
(d)	Brinell Hardness HB	114 (Min.)
(e)	Rockwell Hardness HRB	67 (Min.)
(f)	Vickers Hardness HV	120 (Min.)
(g)	Elongation after fracture % Min.	22%
(h)	Strength under wedge loading	400 (Min.) N/Sq.mm.
(i)	Head Soundness	No fracture
(j)	Cantilever load Kgs.	150 (Max.)
(ii)	For Nuts:	
(a)	Proof stress (N/Sq.mm.)	490 (Max.)
(b)	Vickers Hardness HV (Min.-Max.)	130-302
7	Galvanising	
	(Hot dip mass and eqt. Thickness of coating)	
(a)	Min. average coating	
(i)	Mass g/Sq.M	375
(ii)	Thickness micrometer	54
(b)	Minimum individual coating	
(i)	Mass g/Sq.M	300
(ii)	Thickness micrometer	43
8	Sampling procedure	
(a)	For Step Bolt with two nuts & two plain washers	As per IS:1367 (Part-17)/1996
(b)	Galvanising	IS:1367 Pt-XIII – 1983

GUARANTEED TECHNICAL & OTHER PARTICULARS FOR DANGER PLATE, PHASE PLATE & NUMBER PLATE.

S.NO.	DESCRIPTION	DETAILS
1	Specification & standards	
(i)	General checking	1) Visual as per IS:2551 – 1982 2) Dimensional 3) Description printed
(ii)	Colour Enamelling	Thickness of Enamel & whether proofness as per IS:5 -1978 with latest amendments
(iii)	Resistance to citric acid at room temperature and boiling temperature	As per IS:3972 (Pt-II/Sec-I)-1985 with latest amendments
(iv)	Low & High voltage tests for detecting and locating defects	As per IS:3972 (Pt-2/Sec-II)-1985 with latest amendments
(v)	Production of specimen for testing	As per IS:3972 (Pt-1/Sec-I)-1982 with latest amendments
2	Thickness of M.S. plate	1.6 mm
3	Diameter of holes	
a)	For Danger plate	17.5 mm dia holes
b)	For Phase plate	17.5 mm dia holes
c)	For Number plate	17.5 mm dia holes
4	Colour Enamel	
a)	For Danger plate	The danger plate shall be vitreous enameled coloured white with letters, figures & conventional skull and cross bones in signal red colour conforming to IS-5-1978 on the front side and rear side should be enameled black. Holders for fixing the plates should be drilled not punched.
b)	For Phase plate	The phase plate shall be vitreous enameled coloured both sides with Red, Blue and Yellow for phase representation (Equal quantities)
c)	For Number plate	The number plate shall be vitreous enameled. Red coloured numbers on white background.
5	Marking	Power

GUARANTEED & OTHER TECHNICAL PARTICULARS OF ACSR "PANTHER"

S. No.	Description	ACSR 'PANTHER'
1.	Manufacturer's name and address.	
2.	Type of industry (Small/Medium/Large scale) with their registration No.	
3	Stranding and nominal wire diameter in mm : a) Aluminium b) Steel	30/3.00 7/3.00
4	Nominal Aluminium area in sq.mm	200
5	Sectional area in sq.mm: a) Aluminium Strand. b) Steel strand. c) Conductor.	7.069 7.069 261.5
6	Overall diameter (Approx) of Conductor in mm	21
7	i) Density of hard drawn aluminium at 20 °C in g/cm ³ ii) Density of galvanized steel wire at 20 °C in g/cm ³	2.703 7.8
8	Approximate calculated breaking load of conductor in kN	89.67
9	Minimum breaking load in kN for: a) Aluminium strand : i) Before stranding. ii) After stranding. b) Steel strand : i) Before stranding. ii) After stranding.	1.17 1.11 9.29 8.83
10	Purity of aluminium rods	99.50%
11	Zinc coating of steel strand:(values before stranding). a) Uniformity of coating, number and duration of dips (Preece test): i) Number of dips one min. ii) Number of dips half min. b) Minimum weight of coating in gm/m ² .	3 - 228
12	Maximum working tension in KN	As per IS
13	Mass in kg/ km (Approx.) a) Aluminium b) Steel c) Conductor.	586 388 974
14	Resistance in ohms/km at 20 °C: i) Aluminium wire. ii) Complete conductor	4.079 0.139
15	Modulus of Elasticity in GN/m ² a) Aluminium. b) Steel. c) Conductor	As per IS As per IS 80
16	Co-efficient of Linear Expansion per degree centigrade of : a) Aluminium b) Steel. c) Conductor.(indicate in initial & final both)	23x10 ⁻⁶ 11.5x10 ⁻⁶ 17.8x10 ⁻⁶
17	Percentage of carbon in steel wire rods	0.5 to 0.85%
18	Standard length of each piece in Meters	1400
19	Tolerance on standard length, if any	+/-5%
20	No. of standard lengths in one reel	One

S. No.	Description	ACSR 'PANTHER'
21	Dimensions of the reel in mms. i) Flange dia. ii) Traverse. iii) Barrel dia	1300-1400 700-800 500-630
22	Net weight of the conductor in one reel in Kg.(Approx.).	1363.6 (min.)
23	Standard according to which the conductor will be manufactured and tested	As per IS:398/1996 Pt.II with latest amendment
24	Method of jointing in Aluminium wires (only cold pressure butt welding is permitted as per clause No.10.1 of Volume-III of Bid document).	Cold pressure Butt Welding

PRINCIPLE TECHNICAL PARAMETERS OF ACSR "PANTHER" CONDUCTOR.

S. No.	Particulars	PANTHER
1.	Nominal Aluminium area	200 mm ²
2.	No. of strands and nominal diameter: i) Aluminium ii) Steel	30/3.00 mm 7/3.00 mm
3.	Sectional area of aluminium	212.1 mm ²
4.	Total sectional area	261.5 mm ²
5.	Approximate overall diameter	21.00 mm
6.	Approximate total mass	974 kg/km
7.	Calculated resistance at 20 Degree C.(Max.)	0.139 Ω /km
8.	Approximate calculated breaking load	89.67 kN
9.	Lay ratio: (a) Steel core(six wire layer) (b) Aluminium wire: i) Outer most layer ii) Layer immediately beneath outermost layer	Max.– 28 Min.- 13 Max.– 14 Min.- 10 Max.- 16 Min.– 10
10.	Final Modulus of Elasticity	80 GN/ m ²
11.	Co-efficient of Linear Expansion	17.8 x 10 ⁻⁶ /°C
12.	Ratio of aluminium wire diameter to steel wire diameter	1.000
13.	Standard Length	1400 m \pm 5%

**DETAILS OF SOLID ALUMINIUM AND GALVANISED STEEL WIRE USED IN CONSTRUCTION
OF ALUMINIUM CONDUCTOR GALVANISED STEEL REINFORCED CODE "PANTHER".**

S. No.	Particulars	ACSR "PANTHER"
1	ALUMINIUM WIRE	
i)	Nominal diameter	3.00 mm
ii)	Maximum diameter	3.03 mm
iii)	Minimum diameter	2.97 mm
iv)	Cross Sectional area of nominal diameter wire	7.069 sq.mm
v)	Mass	19.11 kg/km
vi)	Breaking load (Min.):	
a)	Before stranding	1.17 kN
b)	After stranding	1.11 kN
vii)	Resistance at 20 °C (Max.)	4.079 Ω/km
2.	GALVANISED STEEL WIRE	
i)	Nominal diameter	3.00 mm
ii)	Maximum diameter	3.06 mm
iii)	Minimum diameter	2.94 mm
iv)	Cross Sectional area of nominal diameter wire	7.069 mm ²
v)	Mass	55.13 kg/km
vi)	Breaking load (Min.):	
a)	Before stranding:	9.29 kN
b)	After stranding:	8.83 kN

**STATEMENT OF GUARANTEED TECHNICAL PARTICULARS AND
OTHER PERFORMANCE DATA FOR ACSR ZEBRA'**

Appendix-II (A)

PRINCIPAL TECHNICAL PARAMETERS OF ACSR "ZEBRA" CONDUCTOR.

S.No.	Particulars	'ZEBRA'
1.	Nominal Aluminium area (in Sq.mm)	420
2.	No. of strands and nominal diameter (in mm):	
	i) Aluminium	54/3.18
	ii) Steel	7/3.18
3.	Sectional area of aluminium (in sq.mm)	428.9
4.	Total sectional area (in Sq.mm)	484.5
5.	Approximate overall diameter (in mm)	28.62
6.	Approximate total mass (in Kg./Km.)	1621
7.	Calculated resistance at 20 Degree C.(Max. in Ohms/Km)	0.06868
8.	Approximate calculated breaking load (KN)	130.32
9.	Lay ratio :	
	(a) Steel core(six wire layer)	Max. - 28 Min. - 13
	(b) Aluminium wire :	
	i) Outer most layer	Max. - 14 Min. - 10
	ii) Layer immediately beneath outermost layer.	Max. - 16 Min. - 10
	lii) Inner most layer Of conductors with. 3 Al. wire layers	Max. - 17 Min. - 10
10.	Final Modulus of Elasticity(GN/sq.m.)	69
11.	Co-efficient of Linear Expansion/Deg.C.	19.3×10^{-6}
12.	Ratio of aluminium wire diameter to steel wire diameter.	1.000
13.	Standard Length(Mtrs.)	1100 \pm 5%

**DETAILS OF SOLID ALUMINIUM AND GALVANISED STEEL WIRE USED IN CONSTRUCTION OF
ALUMINIUM CONDUCTOR GALVANISED STEEL REINFORCED CODE "ZEBRA".**

S.No.	Particulars	ACSR "ZEBRA"
1.	ALUMINIUM WIRE : -----	
	i) Nominal diameter	3.18 mm
	ii) Maximum diameter	3.21 mm
	iii) Minimum diameter	3.15 mm
	iv) Cross Sectional area of nominal diameter wire.	7.942 sq.mm
	v) Mass	21.47 Kg/Km
	vi) Breaking load(Min.):-	
	a) Before stranding:	1.29 KN
	b) After stranding :	1.23 KN
	vii) Resistance at 20 Deg.C.(Max.)	3.626 Ohm/KM
2.	GALVANISED STEEL WIRE : -----	
	i) Nominal diameter	3.18 mm
	ii) Maximum diameter	3.24 mm
	iii) Minimum diameter	3.12 mm
	iv) Cross Sectional area of nominal diameter wire.	7. 942 sq.mm
	v) Mass	61.95 Kg/Km
	vi) Breaking load(Min.):-	
	a) Before stranding:	10.43 KN
	b) After stranding:	9.91 KN

GUARANTEED AND OTHER TECHNICAL PARTICULARS FOR COUNTERPOISE TYPE AND PIPE TYPE EARTHING SETS

1. SPECIFICATION AND STANDARDS

- | | |
|----------------------------------|--|
| a) For G.I. Pipe | IS: 1239 |
| b) For Galvanised Flat | IS: 2062/2006 Grade "A" |
| c) For G.I. Bolts and Nuts | IS: 12427/2001 & IS: 1367(Part3)2002 |
| d) For Galvanised Spring washers | IS: 3063/1994, IS : 1573/1986 &
IS: 4072/1975 |
| e) For 7/3.15 mm Steel Wire. | IS: 12776/2002 |

2. SIZE

- | | |
|----------------------------------|----------------------------|
| a) For G.I. Pipe | 25 mm dia , 3000mm length |
| b) For Galvanised Flat | 50 mm x 5mm, 5000mm length |
| c) For G.I. Bolts and Nuts | M16 x 40N |
| d) For Galvanised Spring washers | For 16 MM dia bolt M16 –B |
| e) For 7/3.15 mm Steel Wire. | IS: 12776/2002 |

3. TOLERANCE

- | | |
|----------------------------------|---|
| a) For G.I. Pipe | IS: 1239 |
| b) For Galvanised Flat | IS: 1852 |
| c) For G.I. Bolts and Nuts | IS: 12427/2001 & IS 1367 (Part-3) 2002 for bolt
& IS 1367 (Part – 6)/ 1994 for nuts. |
| d) For Galvanised Spring washers | IS: 3063/1994, |
| e) For 7/3.15 mm Steel Wire. | IS: 12776/2002 |

4. RAW MATERIAL

- | | |
|----------------------------------|----------------------------|
| a) For G.I. Pipe | IS: 1239 |
| b) For Galvanised Flat | IS: 2062/2006, Grade –"A". |
| c) For G.I. Bolts and Nuts | IS: 12427/2001 |
| d) For Galvanised Spring washers | IS: 4072/1975 |
| e) For 7/3.15 mm Steel Wire. | IS: 12776/2002 |

5. CHEMICAL COMPOSITION(%)

- | | |
|----------------------------------|---|
| a) For G.I. Pipe | IS: 1239 |
| b) For Galvanised Flat | IS: 2062/2006 |
| c) For G.I. Bolts and Nuts | IS: 12427/1988 & IS 1367 (Part -3) 2002 for bolt
& IS 1367 (Part – 6)/ 1994 for nuts. |
| d) For Galvanised Spring washers | IS: 4072/1975 |
| e) For 7/3.15 mm Steel Wire. | IS: 12776/2002 |

6. MECHANICAL PROPERTIES.

- | | |
|----------------------------------|---|
| a) For G.I. Pipe | IS: 1239 |
| b) For Galvanised Flat | IS: 2062/2006–Grade "A". |
| c) For G.I. Bolts and Nuts | IS: 12427/2001 & IS 1367 (Part - 3) 2002 for bolt
& IS 1367 (Part – 6)/ 1994 for nuts. |
| d) For Galvanised Spring washers | As per IS-4072/1975 |
| e) For 7/3.15 mm Steel Wire. | IS: 12776/2002 |

7. GALVANISING

(Hot dip-Mass and equivalent thickness of Coating.)

a) Minimum Average Coating

Mass	(g/mm ²)	IS: 1367 (Part –XIII)/1983
Thickness	(Micrometer)	IS: 1367 (Part –XIII)/1983

b) Minimum individual coating

Mass (g/mm ²)	IS: 1367 (Part –XIII)/1983	
Thickness (Micrometer)	IS: 1367 (Part –XIII)/1983	
9. <u>Sampling procedure for</u>		
a) For G.I. Pipe	3% of offered qty.	
b) For Galvanised Flat	3% of offered qty.	
c) For G.I. Bolts and Nuts	IS: 1367 (Part –17)/1996	
d) For Galvanised Spring washers	IS: 6821/1973	e) For
7/3.15 mm Steel Wire.	IS: 12776/2002	

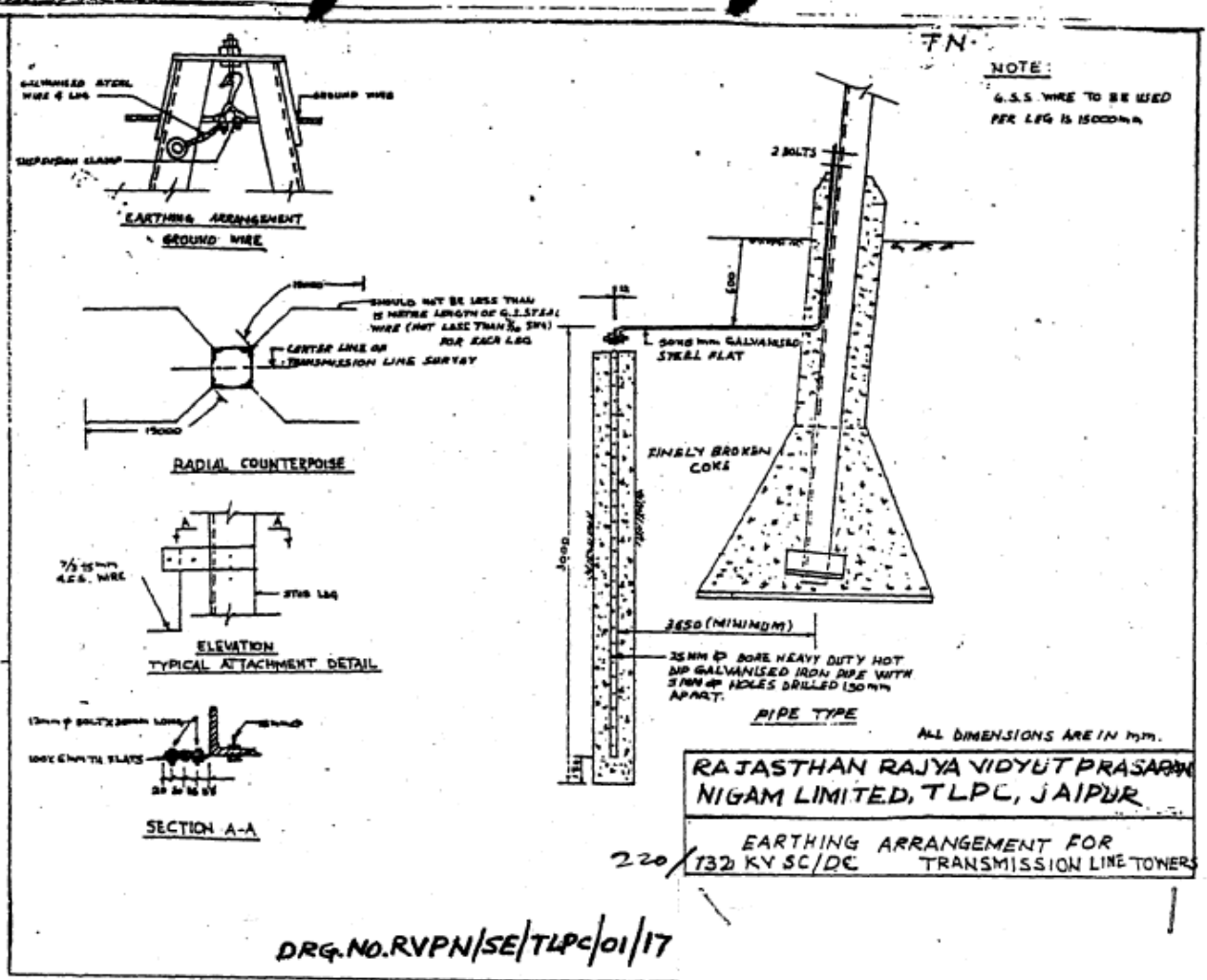
10. Packing Details

(a) (i) Galvanised 7/3.15 mm Steel Wire	In Bundled securely wrapped or four times around at each end with no. 9 SWG gauge wire with end twisted tightly. Gross wt. of any bundle should not exceed approx. 50 Kg.
(ii) G.I. Pipe and G.I. Plate	In Bundled securely wrapped or four times around at each end with no. 9 SWG gauge wire with end twisted tightly. Gross wt. of any bundle should not exceed approx. 50 Kg.
(b) G.I. Bolts & Nuts, washers etc.	Packed in Double Gunny bag.


Appendix-V(1)

LIST OF DRAWINGS RELATING TO LINE MATERIALS


S.NO.	NAME OF ITEM
1	EARTHING ARRANGEMENT FOR 220kV/132kV TRANSMISSION LINE TOWERS
2	DANGER PLATE FOR 132KV
3	PHASE PLATE
4	NUMBER PLATE




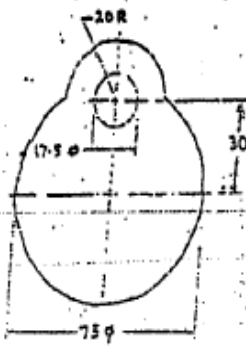
DANGER	
132000 १३२०००	 VOLTS वोल्ट्स
रखतरा इस लाइन की मध्यरेखासे दोनों ओर 13.5 मीटर (45 फीट) तक कोई भी निर्माण वर्जित है	
DANGER PLATE FOR 132 K.V. LINES DRS. H. RVPM / XEM-71463/1003/11 ST. 1-19-12	
SUBMITTED BY  HANU, 20/12/12	APPROVED BY  HANU, 20/12/12


 CE (H/M)
 RVPM, Jaipur


 CE (H/M)
 RVPM, Jaipur


 CE (H/M)
 RVPM, Jaipur


 CE (H/M)
 RVPM, Jaipur



PHASE PLATE

- NOTE
- 1) ALL DIMENSIONS ARE IN MM
 - 2) COLOURED BOTH SIDES WITH RED, BLUE AND YELLOW COLOUR FOR PHASE REPRESENTATION
 - 3) THE PLATES SHALL BE MADE FROM MILD STEEL SHEET OF AT LEAST 1.6 mm THICK
 - 4) THE OTHER DETAILS SHALL BE AS PER SPECIFICATION AND RELEVANT IS

RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LTD
PHASE PLATE
SCALE N.T.S
TN
DRAWING NO SE/TUP/XEN/STEEL/ATT/NO.2

TYPE TESTS

The type tests reports for the following items will be as under:-

(A) Hardware fittings & Accessories for conductor**(i) On Suspension Hardware Fitting:** (IS:2486 part-I/1993 with latest amendment)

- a. Visual examination test
- b. Verifications of dimensions
- c. Slip strength test
- d. Chemical composition test (on string fitting)
- e. Galvanizing test/Electroplating test
- f. Ultimate Strength/ Mechanical Strength test

(ii) On Tension Hardware Fittings (IS:2486 part-I/1993 with latest amendment)

- a. Visual examination test
- b. Verifications of dimensions
- c. Slip strength test
- d. Chemical composition test (on string fitting)
- e. Galvanizing test/Electroplating test
- f. Ultimate Strength/ Mechanical Strength test
- g. Electrical resistance test
- h. Heating cycle test

(iii) Mid Span Compression Joint for Conductor :

(IS:2121 part-II/1981 & part-III/1992 with latest amendment)

- a. Visual examination test
- b. Verification of dimension
- c. Failing load test/slip strength test
- d. Electrical resistance test
- e. Heating cycle test (for conductor only)
- f. Galvanizing test

(iv) Repair Sleeves for conductor

(IS:2121 part-II/1981 with latest amendment)

- a. Visual examination
- b. Verification of dimension
- c. Failing load
- d. Electrical resistance test

(vi) Vibration Damper for Conductor

(IS:9708/1993 with latest amendment)

- a. Visual examination
- b. Verification of dimension
- c. Resonance frequency test
- d. Fatigue test
- e. Mass Pull off test
- f. Dynamic characteristic test
- g. Damping efficiency test
- h. Clamp Slip test
- i. Clamp Bolt Torque test
- j. Galvanising/electroplating test
- k. Magnetic power loss test (for Zebra conductor).

(vii) P.A. Rod (IS:2121 part-I with latest amendment)

- a. Visual Examination
- b. Verification of dimension
- c. Tensile strength test
- d. Electrical resistance test
- e. Slip Strength test
- f. Bend test

- g. Resilient test

(B) Galvanised Bolts & Nuts : (Ref IS:12427)

For Bolts only :

- (a) Tensile test
- (b) Hardness test
 - (i) Rockwell (HRB) test
 - (ii) Vickers (HV) test
 - (iii) Brinells (HB) test
- (c) Proofing load test
- (d) Wedge loading test
- (e) Chemical composition test

For Nuts only :

- (a) Mechanical properties
 - (i) Proofing stress
 - (ii) Vickers Hardness test
- (b) Chemical composition test

For Both Bolts & Nuts :

- (i) Galvanising test (Mass & Thickness)

The galvanised Nuts & Bolts should also bear ISI certification mark.

(C) Spring washers / Washers(Ref IS:3063)

- (a) Chemical composition test (IS 4072)
- (b) Mechanical properties test (IS 3063)
 - (i) Hardness test
 - (ii) Permanent load test
 - (iii) Permanent set test
 - (iv) Twist test
- (c) Galvanising test

(D) Step Bolts.(Ref IS:10238)

- (a) Tensile test
- (b) Hardness test
- (c) Rockwell (HRB) test
- (d) Vickers (HV) test
- (e) Brinells (HB) test
- (f) Proofing load test
- (g) Wedge loading test
- (h) Chemical composition test

(E) On each type of Disc Insulator / Long rod insulators unit

- (a) Verification of dimensions
- (b) Thermal mechanical performance test
- (c) Power frequency voltage withstand and flashover Test (i) dry (ii) wet condition
- (d) Impulse voltage withstand and flashover test (dry)
- (e) Visible Discharge test (dry)
- (f) RIV test (dry)
- (g) Residual strength Test **(only on disc insulators)**
- (h) Steep wave front test **(only on disc insulators)**
- (i) Impact Test **(only on disc insulators)**

Appendix-V(3)

A. Approximate Weight of HT members and MS members in the Nigam's Design Narrow base Towers

S. No.	Item Particulars	HT Members WT. in MT/Tower	MS Members WT. in MT/Tower	Total Wt of members in MT/Tower
1	2	3	4	5
A	220kV D/C Towers (350M Span)			
I	Tower Type A (TTA)			
i)	Stub	0.249863	0.037960	0.287823
ii)	Superstructure	1.671176	2.616570	4.287746
iii)	+3M Extension	0.217837	0.381999	0.599836
iv)	+6M Extension	0.435674	0.784126	1.219800
v)	SST		0.335424	0.335424
II	Tower Type B (TTB)			
i)	Stub	0.586633	0.095824	0.682457
ii)	Superstructure	3.862789	3.967358	7.830147
iii)	+3M Extension	0.444559	0.593022	1.037581
iv)	+6M Extension	0.889118	1.228391	2.117509
v)	SST		0.365834	0.365834
III	Tower Type C (TTC)			
i)	Stub	0.523760	0.021760	0.545520
ii)	Superstructure	2.913840	4.319310	7.233150
iii)	+3M Extension	0.482360	0.629916	1.112276
iv)	+6M Extension	0.964720	1.327860	2.292580
v)	SST		0.668880	0.668880
IV	Tower Type D (TTD)			
i)	Stub	0.772985	0.135128	0.908113
ii)	Superstructure	5.479371	3.868053	9.347424
iii)	+3M Extension	0.581667	0.707941	1.289608
iv)	+6M Extension	1.163334	1.480237	2.643571
vi)	SST		0.583270	0.583270
B	220kV D/C Towers (250M Span)			
I	Tower Type A (TTA)			
i)	Stub	0.283680	0.036540	0.320220
ii)	Superstructure	2.460100	2.518753	4.978853
iii)	+3M Extension	0.457075	0.154875	0.611950
iv)	+6M Extension	0.729250	0.501368	1.230618
v)	SST		0.232104	0.232104
II	Tower Type B (TTB)			
i)	Stub	0.639241	0.034800	0.674041
ii)	S/Str.	3.903279	5.230461	9.133740
iii)	+3M Extension	0.584338	0.964812	1.549150
iv)	+6M Extension	1.168676	1.989326	3.158002
v)	SST		0.359458	0.359458
III	Tower Type C (TTC)			
i)	Stub	0.733772	0.034800	0.768572
ii)	S/Str.	4.315828	6.217362	10.533190
iii)	+3M Extension	0.870548	1.118877	1.989425
iv)	+6M Extension	1.741120	2.365105	4.106225
v)	SST		0.497788	0.497788
D	220kV S/C Towers (350M Span)			
I	Tower Type A (TTA)			

i)	Stub	0.142560	0.022298	0.164858
ii)	Superstructure	0.859818	1.930569	2.790387
iii)	+3M Extension	0.141715	0.363665	0.505380
iv)	+6M Extension	0.283430	0.755639	1.039069
v)	SST		0.348078	0.348078
II	Tower Type B (TTB)			
i)	Stub	0.000	0.297360	0.297360
ii)	Superstructure	0.000	3.715610	3.715610
iii)	+3M Extension	0.000	0.714860	0.714860
iv)	+6M Extension	0.000	1.499370	1.499370
v)	SST	0.000	0.554440	0.554440
III	Tower Type C (TTC)			
i)	Stub	0.000	0.389120	0.389120
ii)	Superstructure	0.000	4.058570	4.058570
iii)	+3M Extension	0.000	0.807600	0.807600
iv)	+6M Extension	0.000	1.659320	1.659320
v)	SST	0.000	0.627000	0.627000
IV	Tower Type D (TTD)			
i)	Stub	0.000	0.460440	0.460440
ii)	Superstructure	0.000	5.364540	5.364540
iii)	+3M Extension	0.000	1.052200	1.052200
iv)	+6M Extension	0.000	2.173600	2.173600
v)	SST	0.000	0.688280	0.688280
E	132kV D/C Towers (150M Span)			
I	Tower Type A (TTA)			
i)	Stub	0.000	0.122840	0.122840
ii)	Superstructure	0.000	2.250100	2.250100
iii)	+6M Extension	0.000	0.898480	0.898480
iv)	SST	0.000	0.225160	0.225160
II	Tower Type B (TTB)			
i)	Stub	0.000	0.409080	0.409080
ii)	Superstructure	0.000	4.602070	4.602070
iii)	+6M Extension	0.000	1.764700	1.764700
iv)	SST	0.000	0.284840	0.284840
III	Tower Type C (TTC)			
i)	Stub	0.000	0.762480	0.762480
ii)	Superstructure	0.000	6.356760	6.356760
iii)	+3M Extension	0.000	1.972490	1.972490
iv)	+6M Extension	0.000	2.716500	2.716500
v)	SST	0.000	0.316360	0.316360

B. Approximate Weight of HT members and MS members in the Nigam's Design 220kV D/C & S/C Normal Towers & 220kV D/C Special Structure (350M span) and 132kV D/C & S/C Normal Towers (335M span)

S. No.	Item Particulars	HT Members WT. in MT/Tower	MS Members WT. in MT/Tower	Total Wt of members in MT/Tower
1	2	3	4	5
A	220kV D/C Towers			
I	Tower Type A (TTA)			
i)	Stub	0.214781	0.000000	0.214781
ii)	Superstructure	1.946227	2.055017	4.001244
iii)	+3M Extension	0.280345	0.310811	0.591156
iv)	+6M Extension	0.476426	0.706631	1.183057

v)	SST	0.000000	0.334923	0.334923
II	Tower Type B (TTB)			
i)	Stub	0.000	0.316	0.316
ii)	Superstructure	0.000	6.650	6.650
iii)	+3M Extension	0.000	1.326	1.326
iv)	+6M Extension	0.000	2.169	2.169
v)	SST	0.000	1.066	1.066
III	Tower Type C (TTC)			
i)	Stub	0.000	0.397	0.397
ii)	Superstructure	0.000	7.500	7.500
iii)	+3M Extension	0.000	1.525	1.525
iv)	+6M Extension	0.000	2.606	2.606
v)	SST	0.000	1.111	1.111
IV	Tower Type D (TTD)			
i)	Stub	0.000	0.549	0.549
ii)	Superstructure	0.000	8.867	8.867
iii)	+3M Extension	0.000	1.657	1.657
iv)	+6M Extension	0.000	2.640	2.640
v)	+9M Extension	0.000	5.069	5.069
vi)	SST	0.000	1.406	1.406
B	220kV S/C Towers			
I	Tower Type A (TTA)			
i)	Stub	0.162154	0.000000	0.162154
ii)	Superstructure	1.439825	1.371267	2.811092
iii)	+3M Extension	0.271642	0.173860	0.445502
iv)	+6M Extension	0.424064	0.534594	0.958658
v)	SST	0.000000	0.243207	0.243207
II	Tower Type B (TTB)			
i)	Stub	0.000	0.223	0.223
ii)	S/Str.	0.000	3.622	3.622
iii)	+3M Extension	0.000	0.720	0.720
iv)	+6M Extension	0.000	1.201	1.201
v)	SST	0.000	0.673	0.673
III	Tower Type C (TTC)			
i)	Stub	0.000	0.267	0.267
ii)	S/Str.	0.000	3.771	3.771
iii)	+3M Extension	0.000	0.612	0.612
iv)	+6M Extension	0.000	1.263	1.263
v)	SST	0.000	0.434	0.434
IV	Tower Type D (TTD)			
i)	Stub	0.000	0.327	0.327
ii)	S/Str.	0.000	4.930	4.930
iii)	+3M Extension	0.000	0.848	0.848
iv)	+6M Extension	0.000	1.701	1.701
v)	SST	0.000	0.596	0.596
C	220kV D/C Special Structure			
i)	Stub	0.000	0.341	0.341
ii)	S/Str.	0.000	5.767	5.767
iii)	+4.5M Extension	0.000	1.499	1.499
iv)	+9M Extension	0.000	3.063	3.063
v)	+18M Extension	0.000	6.248	6.248
v)	SST	0.000	1.258	1.258
D	132kV D/C Towers			
I	Tower Type A (TTA)			
i)	Stub	0.157526	0.000000	0.157526
ii)	Superstructure	1.201401	1.573633	2.775034
iii)	+3M Extension	0.222367	0.253658	0.476025
iv)	+6M Extension	0.345013	0.618040	0.963053

v)	SST	0.000000	0.253672	0.253672
II	Tower Type B (TTB)			
i)	Stub	0.000	0.247	0.247
ii)	Superstructure	0.000	3.301	3.301
iii)	+3M Extension	0.000	0.627	0.627
iv)	+6M Extension	0.000	1.140	1.140
v)	SST	0.000	0.510	0.510
III	Tower Type C (TTC)			
i)	Stub	0.000	0.262	0.262
ii)	Superstructure	0.000	3.744	3.744
iii)	+3M Extension	0.000	0.829	0.829
iv)	+6M Extension	0.000	1.475	1.475
v)	SST	0.000	0.637	0.637
IV	Tower Type D (TTD)			
i)	Stub	0.430800	0.055440	0.486240
ii)	Superstructure	3.131280	2.163380	5.294660
iii)	+3M Extension	0.352360	0.517990	0.870350
iv)	+6M Extension	0.737880	0.938470	1.676350
v)	SST	0.000000	0.420720	0.420720
E	132kV S/C Towers			
I	Tower Type A (TTA)			
i)	Stub	0.112995	0.000000	0.112995
ii)	Superstructure	0.689460	1.217784	1.907244
iii)	+3M Extension	0.214806	0.167083	0.381889
iv)	+6M Extension	0.325348	0.524302	0.849650
v)	SST	0.000000	0.226897	0.226897
II	Tower Type B (TTB)			
i)	Stub	0.000	0.148	0.148
ii)	Superstructure	0.000	2.290	2.290
iii)	+3M Extension	0.000	0.452	0.452
iv)	+6M Extension	0.000	1.004	1.004
v)	SST	0.000	0.389	0.389
III	Tower Type C (TTC)			
i)	Stub	0.000	0.179	0.179
ii)	Superstructure	0.000	2.220	2.220
iii)	+3M Extension	0.000	0.445	0.445
iv)	+6M Extension	0.000	0.979	0.979
v)	SST	0.000	0.489	0.489
IV	Tower Type D (TTD)			
i)	Stub	0.196120	0.024480	0.220600
ii)	Superstructure	1.180080	1.866410	3.046490
iii)	+3M Extension	0.194600	0.418650	0.613250
iv)	+6M Extension	0.357680	0.737490	1.095170
v)	SST	0.000000	0.388120	0.388120

Appendix-V(4)

FOUNDATION VOLUMES & STEEL WEIGHTS OF 220/132KV D/C AND S/C TOWERS

	220kV D/C TTA (New Design)							220kV S/C TTA (New design)						
	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard
Excavation M3	45.160	95.430	77.420	192.000	38.690	76.200	8.100	37.170	71.440	59.140	155.520	28.160	71.440	6.400
Concrete (M-20) M3	4.940	7.870	6.800	13.740	5.770	7.870	4.400	3.750	5.220	4.680	9.760	4.300	5.220	3.710
Concrete (M-10) M3	0.960	2.140	1.710	4.450	1.180	2.140	0.000	0.780	1.570	1.290	3.570	0.850	1.570	0.000
Steel Kg	397.000	571.000	476.000	1228.000	434.000	571.000	206.000	328.000	511.000	439.000	901.000	359.000	511.000	214.000
Ready Mix Grout							0.099							0.06

	220kV D/C TTB							220kV S/C TTB						
	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard
Excavation M3	90.750	90.750	151.230	300.000	81.120		5.310	35.724	48.812	128.580	161.398	23.472		15.585
Concrete (M-15) M3	8.780	8.780	13.970	29.280	10.590		5.460	3.214	3.826	16.376	58.498	6.133		4.198
Concrete (M-10) M3	1.800	1.800	3.170	6.630	2.270				0.778	2.352				
Steel Kg	451.000	451.000	702.000	2045.000	530.000		143.000							

	220kV D/C TTC							220kV S/C TTC						
	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard
Excavation M3	115.320	115.320	201.720	363.000	126.750		8.380		33.215	152.100	139.392	19.688		13.890
Concrete (M-15) M3	11.910	11.910	19.500	36.840	13.940		8.630		2.631	7.692	47.756	7.133		5.293
Concrete (M-10) M3	2.350	2.350	4.330	8.110	2.880				0.365	15.664				
Steel Kg	922.550	922.550	1692.000	3256.000	1012.330		296.000							

	220kV D/C TTD							220kV S/C TTD						
	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard
Excavation M3	184.280	184.280	265.080	476.300	177.870		11.350		41.731	190.046	161.312	23.838		17.300
Concrete (M-15) M3	16.330	16.330	26.360	46.700	18.410		11.596		3.420	9.564	59.618	8.689		6.589
Concrete (M-10) M3	3.470	3.470	5.810	10.800	4.110		0.000		0.450	21.125				
Steel Kg	1586.000	1648.000	2452.510	5841.000	1840.380		341.000							

	220kV D/C TTD (+9M ext)							220kV D/C Special (NT & 4.5M Ext)						
	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard
Excavation M3	184.280		265.080		177.870			44.860		93.000		46.000		13.520
Concrete (M-15) M3	16.450		26.600		18.529			4.010		6.660		5.090		7.550
Concrete (M-10) M3	3.470		5.810		4.107			0.440		1.040		0.540		
Steel Kg	1586.000		2452.510		1840.380					419.000		314.000		

	220kV D/C Special (+9M Ext)							220kV D/C Special (+18 Ext)						
	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard	Dry	Sandy	Wet	WBC	Dry DFR	Wet DFR	Hard
Excavation M3	46.880				48.000		13.520	50.540		101.000		51.000		13.520
Concrete (M-15) M3	4.190				5.250		7.550	4.510		7.020		5.630		7.550
Concrete (M-10) M3	0.470				0.580			0.510		1.130		0.610		
Steel Kg					314.000					520.000		321.000		

