BIDDING DOCUMENT

FOR

CONSTRUCTION OF 132 KV SINGLE CIRCUIT TRANSMISSION LINE ON DOUBLE CIRCUIT TOWERS 132 KV PANCHGRAM SUBSTATION TO STAR CEMENT SUBSTATION AT BURUNGA ON TURNKEY BASIS

VOLUME – 2

TECHNICAL SPECIFICATION

(EMPLOYER'S REQUIREMENT)

ASSAM ELECTRICITY GRID CORPORATION LIMITED

BID IDENTIFICATION NO:- AEGCL/MD/Tech-1090/SCIL/Cachar/2025

VOLUME-2

TECHNICAL SPECIFICATION

CONTENTS

6.3.0 SCOPE

This Section of the specification covers design, manufacture, testing at works of suspension and tension string insulator assemblies for 132 kV transmission lines.

6.1.0 STANDARDS

6.1.1 The suspension and tension string assemblies, insulator discs and hardware offered, material and processes adopted in the manufacture of insulator discs and hardware shall conform to the provision of the following Indian Standards or equivalent other international standards:

(1) IS: 731 Specification of porcelain insulators for overhead power lines.
(2) IS: 2486 Specification of insulator fittings for overhead power lines.
(3) IS: 2026 Specification for recommended practice for hot dip galvanising of steel
(4) IS: 2633 Specification for method for testing uniformity of coating on zinc coated articles.
(5) IS: 2107 Specification for white hearth malleable iron castings.
(6) IS: 2108 Specification for black hearth malleable iron castings.

6.2.0 INSULATOR AND STRINGS

The insulators of the strings shall consist of disc insulators with normal sheds for a three phase, 50 Hz, effectively earthed 132 kV transmission system in a lightly polluted atmosphere. Insulators shall be long rod type with Ball and socket connections.

6.3.1 Insulators shall 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.

6.3.2 Supplier quoting for long rod insulators made of electro porcelain shall also supply intermediate ball pins and intermediate arcing horns along with long rod insulators.

The price of these items shall be considered as including in the price of long rod insulators.

6.3.3 The size disc 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 :

Ball and Socket Designation

The dimensions of the balls and socket shall be of following designation for different for disc insulators in accordance with the standard dimensions stated in IS 2486-(Part-II)/IEC:120:-

Sl. No.	Rating of Insulators	Designation of Ball & socket as per IEC: 120
i)	70 KN	16 mm, AltB
ii)	90 KN	16 mm, AltB
iii)	120 KN	20 mm
iv)	160 KN	20 mm

2.4 **Dimensional Tolerance**

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

± (0.04 d + 1.5) mm when d < 300 mm.

± (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.

2.5 Intermediate Ball Pin Designation

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

2.6 Intermediate Arcing Horn

2.6.1 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 as shown in the specification shall also be provided.

The total effective arcing distance shall be 3050 mm for 400 kV line, 1800 mm for 220 kV line and 1200 for 132 kV line under nominal dimensions of insulator.

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

2.7 **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.

2.8 **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.

2.9 **Maintenance**

2.9.1 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.

2.9.2 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.

2.10 **Materials**

2.10.1 **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.

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

4.2 The Bidder shall furnish along with the bid the outline drawing (6 copies) of each insulator unit including a cross sectional view of the insulator shell. The drawing shall include but not limited to the following information:

(a) Shell diameter and ball to ball spacing with manufacturing tolerances

(b) Minimum Creepage distance with positive tolerance

(c) Protected creepage distance

(d) Eccentricity of the disc

(i) Axial run out

(ii) Radial run out

(e) Unit mechanical and electrical characteristics

(f) Size and weight of ball and socket parts

(g) Weight of unit insulator disc/long rod units

(h) Materials

(i) Identification mark

(j) Manufacturer's catalogue number

SECTION-1

SCOPE AND GENERAL TECHNICAL CONDITIONS

1.1.0 INTENT OF THE SPECIFICATION

1.1.1 This Volume of the specification deals with the information & criteria for manufacture, supply, erection, testing and commissioning and setting to work of 132 KV Transmission lines, tower super structures, conductor, insulators, ground wire and accessories and erection of 132 KV Transmission lines as "Turnkey Contract" as defined in Volume 1.

1.2.0 SCOPE

1.2.1 The work involves design (as applicable), engineering, manufacture, assembly, inspection, testing at manufacturer's works before dispatch, packing, supply, including insurance during transit, delivery at site, subsequent storage, civil foundation work, erection and commissioning at site.

1.2.2 The scope under this Bid covers briefly the following:

(i) Verification / review of the line route of original route survey. The Employer has already conducted a route survey with modern technique of survey of the line. However, the Contractor will be required to do the detailed and check survey of the entire line. The Contractor shall carry out any such modifications to the original route survey as and where required. The documents of the original route survey of the lines will be made available to the successful Bidder.

(ii) Check Survey and preparation and submission of final line profiles, sag template, tower schedules etc. for approval of the Employer. Tower spotting data, tower, gantry drawing including foundation drawing will be provided by AEGCL.

(iii) Fabrication & supply of all type 132 kV transmission line towers and tower material as per the design as per drawings supplied by the Employer including bolts, nuts, washers, hangers, shackles and all type of tower accessories like phase plates, number plates, danger plates, anti-climbing devices.

(iv) Supply of conductor, earth wire, hardware fittings, conductor & earth wire accessories.

(v) Casting of tower foundations as per the drawings supplied by the Employer.

(vi) Erection of towers, tack welding of bolts and nuts including supply and application of zinc rich primer & enamel paint, painting of towers for aviation requirements (if required)

(vii) Supply & providing tower earthing, supply & fixing insulators, insulator strings.

(viii) Stringing of conductor & OPGW along with all necessary line accessories.

(ix) Testing & commissioning of the erected transmission lines.

(x) Other items not specified in this specification and / or Bid form, price and other schedules but are required for the successful completion, commissioning, efficient operation & reliability of the transmission lines, unless specifically excluded in the specification.

1.2.3 The various item of work is described very briefly in the schedule of Bid Form, prices & Other Schedules. The various items as defined in these schedules shall be read in conjunction with the corresponding section in the technical specifications including amendments and, additions if any.

The Bidder's rates shall be based on the description of activities in the schedules as well as necessary operations detailed in Technical Specifications.

1.2.4 It is not the intent to specify completely herein, all details of design and construction of the equipment and accessories, However, the equipment and accessories shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous operation up to the bidder's guarantees in a manner acceptable to the Purchaser, who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material which in his judgement is not in full accordance therewith.

1.2.5 Whether called for specifically or not, all accessories and work required for the completion of the work are deemed to be considered as a part of the bidder's scope supply, unless and until mentioned very clearly in exclusions.

1.2.6 The rates quoted shall include minor details which 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.

1.2.7 The rates quoted shall be inclusive of all plant equipment, men, material, skilled & unskilled labour etc. essential for satisfactory completion of various works.

1.2.8 All measurements for payment shall be in SI Units; lengths shall be measured in meters corrected to two decimal places. Areas shall be computed in square metres and volume in cubic metres, rounded off to two decimal places.

1.2.9 This specification includes supply of hardware fittings and all type of accessories for Conductor and OPGW as detailed in the specification. Contractor shall clearly indicate in their offer, the source from where they propose to procure these materials in appropriate schedule of Bid Form, prices & other schedules. The technical description of these items is given in subsequent sections of this volume.

1.2.10 All raw material such as Structural Steel, Zinc for Galvanizing, reinforcement steel and cement for tower foundations, coke and salt for tower earthing , conductor / earth wire, insulators, line hardware etc. bolts, nuts, washers, D-shackles, hangers, links, danger plates, phase/ number plates etc. required for tower manufacture and erection shall be included in the contractor's scope of supply. Bidders shall clearly indicate in their offer, the source from where they propose to procure the raw materials and the components.

1.2.11 ***The tentative Schedule of Quantities are furnished in Annexure-I, Annexure-II and Annexure-III at the end of this Section. Bidders are requested to note the following points:***

(a) The items mentioned in these Annexure shall only be used while preparing the Price Schedules. If any items which is not specifically mentioned in Annexure-I annexure-II and Annexure-III; but required to complete the works as per Specification shall deemed to be included in any of the items of these Annexure. Additions, deletions or modification of these items while preparing the Price Bid by the Bidder shall render his bid non responsive.

(b) The quantities are provisional in nature and for bidding purpose and for bid comparison purpose only. Quantities may vary to the extent of (+) 15 % to (-) 15% in terms of total Contract Price.

1.2.12 The quantities mentioned in Schedule-I and Schedule-II are based on the walkover survey made by the Employer. It is expected that the Contractor will further optimise the requirement

towers and tower foundations based on the detailed and Check Survey made by the Contractor.

1.3.0 DETAILS OF TRANSMISSION LINE ROUTES AND TERRAIN

1.3.1 The route alignment survey has been carried out by the employer. The details collected through surveys viz, the line route, general soil characteristics, crossings, accessibility, infrastructure details etc will be provided to the successful Bidder.

1.3.2 Bidders may visit the line route to acquaint themselves with the terrain etc., of the proposed transmission lines. For this purpose they are requested to contact the following address:

The Chief General Manager(PP&D)
Assam Electricity Grid Corporation Limited,
Bijulee Bhawan,
Paltan Bazar, Guwahati – 781 001,
Assam

1.4.0 CONTRACTOR TO INFORM HIMSELF FULLY

1.4.1 The contractor should ensure that he has examined the General Conditions, Specifications and Schedules as brought out in Volume-1 and has satisfied himself as to all the conditions and circumstances affecting the contract price and fixed his price according to his own views on these matters and acknowledge that no additional allowances except as otherwise provided therein will be levied.

1.4.2 The Employer shall not be responsible for any misunderstanding or incorrect information obtained by the contractor other than information given to the contractor in writing by the Employer

1.5.0 ACCESS TO THE LINE AND RIGHT OF WAY

1.5.1 *Right of way and the way leave clearances shall be arranged by the Employer in accordance with the work schedules. Employer will secure way leave and right of way in the Forest area also (if any)**. However, it is responsibility of the Contractor to clearing of all obstacles along the right of way of the transmission line routes, like cutting of trees, jungles and removal of structures etc. The Bidder shall include the cost of this works in rates quoted for survey/erection/stringing of the lines***.

1.6.0 BASIC TECHNICAL DATA

1.6.1 **Service Conditions** :

The lines covered under this contract are to run entirely in the State of Assam, India and shall be suitable for the tropical climatic conditions prevailing in the area as listed below.

a)	Peak ambient day temperature in still air			-	45°C
b)	Minimum night temperatures			-	0°C
c)	Reference ambient day temperature			-	45°C
d)	Relative Humidity	a)	Maximum	-	100 %
		b)	Minimum	-	10 %
e)	Altitude:	Below1000 M above MSL			
f)	Maximum wind pressure:	As per IS: 802 latest code (Zone-6)			
g)	Other Data:	Refer Meteorological data pertaining to the locations.			

1.6.2 Basic System Data

SL. No	Description	132 KV
1.	Nominal system voltage KV rms	132
2.	Highest system voltage KV rms	145
3.	System of grounding	Solidly Grounded
4.	Impulse insulation level KV peak	650
5.	Power frequency withstand voltage (wet) KV rms	260
6.	Protective shielding angle against direct lightning	NOT EXCEEDING 30^0
7.	Minimum Corona extinction voltage at 50Hz AC system Dry condition (phase to earth)	Not less than 154 kV
8.	Accessories for conductor and Earth wire	i. Preformed armour rods ii. Mid-Span compression joints iii. Repair sleeves iv. Flexible copper bonds v. Vibration dampers vi. Suspension clamps for earth wire vii. Tension clamp for earth wire
9.	Insulator String Hardware	i. Anchor shackle ii. Chain link iii. Yoke plate iv. Ball clevis v. Arcing horn holding plate vi. Socket clevis vii. Arcing horns viii. Clevis eye ix. Free centre type/armour grip suspension clamp for suspension strings x. Compression type dead end clamp xi. Balancing weight

1.6.3 Basic Design Parameters

Item	Particulars	132 kV Line (Single/double- 3phase) with ACSR	
1. SPAN	(i) Normal span (Design Span)	335 M	
	(ii) Wind span	335 M	
	(iii) Weight span, both span (total)	Suspension	Tension
	a) Maximum	505 M	505 M
	b) Minimum	185 M	0 M
	(iv) Weight span, one span	Suspension	Tension
	a) Maximum	315 M	315 M
	b) Minimum	100 M	-200 M
2. TEMPARATURE RANGE		Conductor	Earth Wire
	(I) Maximum	85^0C	53^0C
	(ii) Minimum	0^0C	0^0C
	(iii) Every Day	32^0C	32^0C
3. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
4. CONDUCTOR	(i) Material	ACSR	
	(ii) Number of strands & size	Al: 30/ 3.00 mm St: 7/ 3.00 mm	

Item	Particulars	132 kV Line (Single/double- 3phase) with ACSR
	(iii) No. of conductor per phase	1
5. Optical GROUND WIRE	(i) Type	As per technical Specs provided
	(ii) Size	As per technical Specs provided
	(iii) No. of Optical GROUND WIRE	1
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	720 N/m^2
8.GROUND CLEARANCE (Under maximum sag)	(i) Rough country	6100 mm plus sag corrections
	(ii) Across and along all roads and paths	6100 mm Plus sag corrections & allowances
10. Tension Limits	(a) For conductor and ground wire (i) at 32^0 C &no wind (ii) at 32^0 C &full wind (iii) at 0^0 C & 36% of full wind	 25 % of UTS 70 % of UTS 70 % of UTS

1.7.0 DRAWINGS AND DOCUMENTS

1.7.1 In addition to those stipulated in clause regarding drawings in Volume -1, the following also shall apply in respect of Contractor Drawings.

1.7.2 Each drawing submitted by the Contractor for approval of the Employer shall be clearly marked with the name of the Employer, the specification title, the specification number and the name of the Project. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in S.I. units.

1.7.3 The approval of the documents and drawings by the Employer shall mean that the Employer is satisfied that:

a) The Contractor has completed the part of the Works covered by the subject document (i.e. confirmation of progress of work).

b) The Works appear to comply with requirements of Specifications.

In no case the approval by the Employer of any document does imply compliance with neither all technical requirements nor the absence of errors in such documents. If errors are discovered any time during the validity of the contract, then the Contractor shall be responsible of their consequences.

1.7.4 All drawings shall be prepared using AutoCAD software . Drawings which are not compatible to AutoCAD software shall not be acceptable. After final approval all the drawings shall be submitted to the Employer.

1.7.5 The following is the general list of the documents and drawings that are to be approved by the Employer:

a) Work Schedule (Master Network) Plan with linkages prepared on latest version of Microsoft Projects.

b) Final survey report and profile drawings showing all details such as ground clearance, tower locations, deviation angle etc.

c) Tower schedule and foundation classification for individual tower locations

d) Tower structural drawing and bill of materials.

e) Soil Investigation report.

f) Foundation working drawings/excavation Plan.

g) Tower footing earthling drawing.

h) Stringing procedure and stringing chart.

i) Quality plans for fabrication and site activities including Quality System.

j) Sub-vendors approval, etc.

k) Line material drawings.

l) Type test report for line materials.

1.7.6 All Designs / Drawings / Calculations/ Data submitted by the contractor, from time to time shall become the property of the Employer and Employer has the right to use or replicate such designs for future contracts / works without the permission of the Contractor. The Employer has all rights to use/ offer above designs/drawings/data sheets to any other authority without prior Permission of the Contractor.

1.8.0 QUALITY ASSURANCE AND INSPECTION

1.8.1 Quality Assurance

To ensure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his Sub Contractor's premises or at site or at any other place of work are in, accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of Contract. A quality assurance programme of the Contractor shall generally cover but not limited to the following:

a) His organization structure for the management and implementation of the proposed quality assurance programme

b) Documentation control System.

c) Qualification data for Contractors key personnel.

d) The procedure for purchases of materials, parts components and selection of sub-Contractors services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

e) System for shop manufacturing including process controls and fabrication and assembly 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 for quality audits.

k) System for authorizing 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 relevant to each item of supply.

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

1.8.2 **Quality Assurance: Documents**

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employers inspection of equipment/material.

The Employer or his duly authorized representatives reserves the right to carry out Quality Audit and quality surveillance of the systems and procedures of the Contractors/his vendors Quality Management and Control Activities.

1.9.0 TESTS AND STANDARDS

1.9.1 The type, acceptance and routine tests and tests during manufacture shall be carried-out on the material and shall mean as follows:

- 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 shall be carried out on samples prior to Commencement of commercial production against the order. The Bidder shall indicate his schedule for carrying out these tests.
- Acceptance Tests shall mean those tests, which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.
- 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.
- Tests During Manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied by him.
- The norms and procedure of sampling for these tests will be as per the Quality Assurance Programme to be mutually agreed to by the Contractor and the Employer.
- 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 or as mutually agreed to between the Contractor and the Employer in the Quality Assurance Programme.
- For all type and acceptance tests, the acceptance values shall be the values specified in this Specification or guaranteed by the Bidder, as applicable.

1.10.0 TEST REPORTS

1.10.1 Equipment, which has never been tested for critical performance, shall not be accepted. In such cases, a promise or agreement by a bidder to have the equipment tested after award of a contract is not acceptable.

1.10.2 All Bids must be accompanied by the Type/Performance Test Certificates of equipment offered (refer ***Clause 1.10.5*** below). Such type test certificates shall be acceptable only if:-

(a) **Tests are conducted in an independent and well known testing laboratory, *or***

(b) **Tests are conducted in manufacturer's own laboratory. In this case (i) the laboratory must have ISO 9000 (or its equivalent) series certification; and (ii) tests have been witnessed by technically qualified representatives of earlier clients or purchaser.**

1.10.3 **Test reports to be acceptable must be related directly to the equipment/material offered i.e. it is fully identical in design, rating and construction with the equipment for which the type test certificates have been submitted. Test reports for of similar equipment /materials are acceptable with commitment to perform the type/performance tests free of any charge on the particular equipment after the award of contract.**

1.10.4 **Type Test Reports older than ten (10) years on the date of Technical bid opening shall not be accepted.**

1.10.5 **Full Type Test /Performance Test Reports of at least the following equipment must be submitted along with the Bid: -**

1. **Power Conductors.**
2. **Disc Insulators.**
3. **OPGW**

1.11.0 GUARANTEED TECHNICAL PARTICULARS

1.11.1 The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders with Technical Bid in the prescribed schedules of the Specifications. The Bidder shall also furnish any other information's as in their opinion is needed to give full description and details to judge the item(s) offered by them.

1.11.2 The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum/maximum value required as per the technical specification. No preference what *so* ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

1.12.0 COMMISSIONING SPARES

1.12.1 It will be the responsibility of the Contractor to provide all commissioning spares required for initial operation till the Employer declares the equipment as ready for commissioning. All commissioning spares shall be deemed to be included in the scope of the Contract at no extra cost to the Employer.

1.12.2 These spares shall be received and stored by the Contractor at least 3 months prior to the schedule date of commencement of commissioning of the respective equipment and utilized as and when required. The unutilised spares and replaced parts, if any, at the end of successful completion of performance and guarantee test shall be the property of the Contractor and he will be allowed to take these parts back at his own cost with the permission of Project Manager.

1.13.0 CONFORMITY WITH INDIAN ELECTRICITY RULES & OTHER REGULATIONS

1.13.1 The contractor shall note that all overhead power lines shall comply with the latest provisions of Indian Electricity Rules and with any other regulations. Local authorities concerned in the administration of the rules and regulation relating to the power lines shall be consulted, if necessary, in regard to the rules and regulations that may be applicable. Highway department and aerodrome authorities shall also be consulted whenever power lines run near or across the area under their jurisdiction.

1.14.0 CONTRACTOR'S REQUIREMENT

1.14.1 The Contractor should be in possession of a valid E.H.V. Electrical Licence issued by the Chief Electrical Inspector, Govt. of Assam, as per the provision of Law. An attested copy of the aforementioned Licence must be handed over to the Owner for his record prior to handing/ taking over of sites. The Employer/ his representative will give necessary assistance to the contractor in obtaining license from statutory authorities.

1.14.2 All the works shall also be inspected by the Chief Electrical Inspector, Govt. of Assam or his authorised representatives. It is the responsibility of the Contractor to obtain pre-requisite commissioning clearance of any equipment from the said Inspectorate. The Contractor will pay necessary fees to the Inspectorate, which it may levy.

1.14.3 It is obligatory on the part of contractor to obtain prior approval from the Employer regarding the guaranteed technical particulars of all the equipment ordered on the vendors before effecting purchase.

1.14.4 The Contractor shall provide necessary drawings and documents required by statutory authorities and obtain the approval before taking up erection. The Employer/ his representative will give technical assistance to the contractor in obtaining approval from statutory authorities.

Annexure -1
SCHEDULE OF QUANTITY

(Note∅: Please refer BOQ)

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2.

SECTION-2

SURVEY AND OPTIMISATION OF TOWER LOCATION

(TECHNICAL SPECIFICATIONS)

2.1.0 SCOPE

2.1.1 Verification / review of the line route of original route survey. The Employer has already conducted a route survey with modern technique of survey of the line. However, the Contractor will be required to do the detailed and check survey of the entire line. The Contractor shall carry out any such modifications to the original route survey as and where required. The documents of the original route survey of the lines will be made available to the successful Bidder. Under the Check Survey following activities are included in the scope of this Bid:

a) Review and verification of tower spotting data of original route Survey reports and optimisation of tower locations.
b) Preparation of final route profile, tower schedule, tower plotting data etc after Check Survey.
c) Locating and peg marking the tower positions on ground conforming to the approved profile and tower schedule.

2.1.2 The Contractor 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.

2.2.0 DETAILED AND CHECK SURVEY

2.2.1 The detail and check survey shall be conducted to locate and peg mark the tower positions on ground conforming to the supplied profile and tower schedule. In this process, it is necessary to have the pit centres marked according to the excavation marking charts. The levels, up or down of each pit centre with respect to the centre of the tower location shall be noted and recorded for determining the amount of earthwork required to meet the approved design parameters. Unequal leg extensions may be provided to reduce benching and leg revetment.

2.2.2 While carrying out the Check Survey works following stipulations shall be followed.

2.2.3 All elevations shall be referenced to benchmarks established by the survey of India. Levelling operations shall begin and end at benchmarks approved by the Employer.

2.2.4 During the levelling of the profile check surveys will be affected at intervals not exceeding 50 kilometres with benchmarks of known elevations. The difference in elevations as surveyed by Contractor and as declared by the survey of India for these benchmarks shall not exceed the precision required for 3rd order surveys, i.e. $e<24/k$, where K is the distance between benchmarks in km and e is the distance in elevations in mm.

2.2.5 All-important objects and features along the transmission line, centreline (railways, highways, road, 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.

2.3.0 FINAL PROFILING AND TOWER SPOTTING

2.3.1 Based on the original survey (reconnaissance) report supplied by the Employer and after making the Detailed & Check Survey the Contractor shall prepare the final tower plotting data and profile based on sag template prepared fresh by the Contractor himself.

2.3.2 Profile shall be plotted and prepared to scale of 1 :2000 horizontal & 1 :200 vertical on 1.0, 10 mm squared paper as per approve procedure. Reference levels at every 20 metres along the profile are also to be indicated on the profile besides, R/Ls at undulations. Areas along the profile Sheet, in the view of the contractor, are not suitable for tower spotting, shall also be clearly marked on the profile plots. If the difference in levels be too high, the chart may be broken up accordingly to requirement. A 10mm overlap shall be shown on each following sheet. The chart shall progress from left to right. Sheet shall be 594 mm wide in accordance with the relevant standard. For 'as built' profile these shall be in A 1 size.

2.3.3 With the help of prepared 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 C type or D type towers as applicable.

(b) **Extension**

An individual span shall be as near to the normal design span as possible. In case of an individual span where ground clearance cannot be maintained 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 extension designed as stipulated elsewhere in this 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 uplift is unavoidable, it shall be examined if the same can be overcome by adding standard body extensions to the towers failing which tension towers designed for the purpose shall be employed at such positions.

(d) **Benching**

In hilly/mountainous regions, when benching might be required, Contractor shall make contour measurements along with the calculation for the volume of Benching and revetment, so that a decision can be made whether to accept benching and/or use unequal leg extensions for a particular site. Benching shall be resorted to only after approval from Employer.

(e) **Road Crossing**

At all important road crossings, the tower shall be fitted with double suspension or tension insulator strings depending on the type of tower but the ground clearance at the roads under maximum conductor design temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not be less than specified with maximum conductor sag. At all national highways tension towers shall be used and crossing span will not be more than 250 meters.

(f) **Railway Crossings**

The entire railway crossings coming-en route the transmission line has already been identified by the Employer. At the time of check 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 crossing shall normally be at right angle to the railway track.
ii 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
iii No crossing shall be located over a booster transformer, traction switching station, traction sub-station or a track cabin location in an electrified area.
iv Minimum ground clearance above rail level *of* the lowest portion *of* any conductor under condition *of* maximum sag shall be maintained at 17.90 metres.
v The crossing span will be limited to 300 meters.

The approval for crossing railway track shall be obtained by the Employer 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 Employer.

(g) **River Crossings**

In case *of* Major River crossing towers shall be of suspension type and the anchor towers on either side *of* the main river crossing shall be 'A' type tower. For navigable rivers the clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL) and shall be 15.0 meters with maximum conductor sag.

(h) **Power line Crossings**

Where this line is to cross over another line of the same voltage or lower voltage, any available 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 / IS: 5613 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). All the works related to the above proposal shall be deemed to be included in the scope of the Contractor except if modifications are required to line below, in which case, the conditions to be agreed upon.

(i) **Telecommunication Line Crossings**

The angle of crossing shall be as near to 90 degree possible. However, deviation to the extent of 30 degree may be permitted under exceptionally difficult situations. When the angle *of* crossing has to be below 60 degree, the matter will be referred to the authority in charge of the telecommunication system. On a request from the Contractor, the permission of the telecommunication authority may be obtained by the Employer.

Also, in the crossing span, power line support will be as near the telecommunication line as possible, to obtain increased vertical clearance between the wires.

The design minimum clearance between the 220kV Conductors and telecommunication lines shall be with maximum conductor sag.

(j) **Details En-route**

All topographical details, permanent features, such as trees, building etc. 50m on either side of the alignment shall be detailed on the profile plan.

(j) **Clearance from Ground, Building, trees etc**

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the Indian Electricity Rules, 1956 / IS 5613 as amended up to date.

2.3.4 The final sag-template curve diagram, profile sheets, duly spotted, along with the schedules indicating type of towers, type of foundations, wind span, weight span, angle of deviation, river of 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 Employer for record purpose

2.3.5 The Contractor shall also submit two numbers of the final template, prepared on rigid transparent plastic sheet to the Employer for the purpose of checking the tower spotting. The templates shall be on the same scale as that of the profile.

2.4.0 SOIL RESISTIVITY MEASUREMENT

2.4.1 Soil resistivity along the route alignment shall be measured in dry weather by four-electrode method keeping inter-electrode spacing of 50 meters. For calculating soil resistivity formula 2πar (where a=50 metres and r = megger reading in ohms) shall be adopted. Measurement shall be made at every 2 to 3 kms along the route of transmission lines. In case soil characteristic, changes within 2 to 3 kms, the value shall also have to be measured at intermediate locations. The megger reading and soil characteristics shall also be indicated in the soil resistivity results.

2.5.0 SOIL TESTING

2.5.1 Type of foundation has already been classified. However soil testing in some locations may be required depending upon the site condition. Accordingly each foundation shall be classified to one of the four types specified in section - 4 of this Volume and approval shall be taken from the competent authority of AEGCL

2.6.0 RIGHT OF WAY, TREE CUTTING ETC.

2.6.1 The tree cutting shall be the responsibility of the Contractor. The Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut at the time of actual execution of the work as detailed below. 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 fault.

2.6.2 Any way leave, which may be required by the Contractor for survey, shall be arranged by the Employer as required by work programme.

2.6.3 To evaluate and tabulate the trees and bushes coming within 50 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 metre from ground level. The trees list should contain the following:

i. Girth (circumstances) measured at a height of 1 metre from ground level.

ii. Approximate height of the tree with an accuracy of +2 metres.

iii. Name of the type of the species/tree.

iv. The bushy and under growth encountered in the 52 m belt should also be evaluated with its type, height, girth and area in square metres, clearly indicating the growth in the tree/bush statement.

2.6.4 Payment of compensation towards value of trees, crops, buildings etc. to be cleared as identified in clause 2.6.1 will be the responsibility of the Employer.

2.7.0 ENVIRONMENTAL CONDITIONS

2.7.1 Forest

The line route passing through forest stretches for various transmission lines covered under this specification shall be furnished to the successful Bidder.

2.7.2 General Climatic Conditions

Climatic conditions shall be of tropical nature having summer period for 8 months and winter period for 4 months in a year. Working season shall be approximately 7-8 months/year and balance 4-5 months shall be monsoon period. The maximum temperature during summer shall be of the order of 45 Degrees Centigrade and the minimum temperature in the winter shall be of the order of 4 Degrees Centigrade Normal everyday temperature is 32 Degrees Centigrade.

2.8.0 STATUTORY REGULATIONS AND STANDARDS

2.8.1 Statutory Regulations

The Contractor is required to follow local statutory regulations stipulated in Electricity (Supply) Act, Indian Electricity Rules as amended and other local rules and regulations referred in this Specification.

2.8.2 Reference Standard

The Codes and/or standards referred to in the specifications shall govern in all cases wherever such references are made. In case of a conflict between such codes and/or standards and the specifications, latter shall govern. Such codes and/or standards, referred to shall mean the latest revisions, amendments/changes adopted and published by the relevant agencies unless otherwise specified. Other internationally accepted standards, which ensure equal or better performance than those specified shall also be accepted, subject to prior approval by the Employer.

SECTION-3

SPECIFICATION FOR DESIGN AND FABRICATION OF TRANSMISSIONLINETOWERS

(TECHNICAL SPECIFICATIONS)

3.1.0 SCOPE

3.1.1 This section covers the design, fabrication, galvanising, supply and delivery at site of galvanised steel structures, bolts & nuts, tower accessories etc. for transmission line towers covered under this Bid Document and as per Specification.

3.1.2 **Design of structures is not in the scope of Bidders for this package. The structures shall be supplied on the basis of drawings supplied by the Employer**. However, in case any special tower or structure is required but is not covered in the bidding document, the Employer may ask the Contractor to design and supply such structure.

3.2.0 GENERAL DESCRIPTION OF THE TOWER

3.2.1 General

3.2.1.1 The towers shall be of self-supporting hot dip galvanized lattice steel type designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

3.2.1.2 The tower shall be fully Galvanised using mild steel or / and high tensile steel sections. Bolts and nuts with spring washer are to be used for connections.

3.2.2 Type of Towers

3.2.2.1 Normal Towers

The towers for transmission lines are classified as given below. The bidder shall design and quote for the following four types of towers (Standard/Standard Towers):

Tower type D shall also be used as a Dead End tower.

Type of Tower	Deviation Limit	Typical Use
A	0 – 2 deg.	To be used as tangent tower with single or Double suspension Insulator String
B	2 - 15 deg.	a) Angle towers with Single / Double Tension insulator string.
C	15 - 30 deg.	a) Angle tower with single or /and double tension insulator string. b) Also to be used for locations where uplift exist. c) Section tower for anti-cascading condition.
D	30 - 60 deg/ Dead End.	a) Angle tower with Single or / and Double tension insulator string. b) Also to be used for locations where uplift exist. c) Dead end with 0 deg. to 15 deg. deviation both on line side and substation side (slack span)

The angles of line deviation specified are for the design span. The span may however be increased up to an optimum limit with reduced angle of line deviation if adequate ground and phase clearances are available. For this purpose the Contractor shall prepare a tower rating chart (weight/wind span as function of various angles of deviations).

3.2.2.2 **Special Towers**

In case a defined type of Towers cannot be used at certain location(s), the Contractor may be asked to submit design of such towers/structures for such locations and payments shall be made at unit rates of other type of towers.

3.3.0 SPANS AND CLEARANCES

3.3.1 Normal span, Wind Span & Weight Span

The normal ruling span, wind span and weight span to be adopted for lines covered under this Specification are specified in Clause 1.6.0, Section-1of this Volume along with all other parameters.

3.3.2 Electrical Clearances

3.3.2.1 Ground Clearance

a) The minimum ground clearance *of* conductors above ground shall not be less than the limits specified in Line Data at 1.6.0, Section-1 of this volume, at a conductor temperature *of* 85°C and in still air. However, to achieve the above clearance the standard tower heights include the following additional allowances:

b) 150 mm to account *for* errors in stringing;

c) Conductor creep as calculated by over tensioning the conductor at a temperature *of* 30°C lower than the stringing temperature or as determined from the sag-tension tables, which include the final sags including the effects *of* creep.

3.3.2.2 Clearances of live parts form cross arm & towers

The minimum clearances shall be adopted from the following Table.

SL. No	Item	Swinging in degrees	Minimum electrical clearances for line voltage 132 kV
1	SUSPENSION STRINGS		
	(a) Single suspension string	Nil	1530 mm
		15°	1530 mm
		30°	1370 mm
		45°	1220 mm
		60°	1070 mm
	(b) Double suspension string	Nil	1530 mm
2	TENSION STRING Single / double	Nil	1530 mm
3	JUMPER	Nil	1530 mm
		10°	1530 mm
		20°	1070 mm
		30°	1070 mm
4	Min. Vertical distance between conductor or cross arms (Single or double circuit)		3900 mm
5	Min. Horizontal distance between conductors (Single or double circuit)		6800 mm

3.3.2.3 **Railway Crossings, etc.**

For railway crossing the clearances from the lowest conductor points to the rail level shall not be less than what is required to comply in all respects with the "Regulation governing the placing of transmission lines across railway tracks" issued by the railway board. In case of trunk road crossings, the clearance from the lowest conductor point to road level shall not contravene the provision of IE rules. Power and Tele-communication line crossings are to be constructed strictly in accordance with provision of IE Rules.

3.4.0 DESIGN DRAWINGS

3.4.1 The relevant drawings for all the towers and their extensions (if applicable) shall be furnished by the Contractor to the Employer which shall include structural/erection drawings, shop fabrication drawings, Bill of Materials, foundation working drawings.

3.4.2 The structural/erection drawings, Bill of materials and shop fabrication drawings for all the towers and their extensions shall be submitted as specified in this Bid document. Documents shall be submitted in four copies and will be finally approved by the Employer. The mass/fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the Contractor shall ensure that all the tower members can be fitted while erecting without any undue strain on them.

3.4.3 The tower accessories drawings like name plate, danger plate, phase plate, anti-climbing device, step bolt, D-shackle etc. shall also be prepared by the Contractor and shall be submitted to the Employer, in three copies, along with one reproducible, for record. These drawings shall be prepared in **A4** size only.

3.4.4 All the drawings shall 'have a proper name plate clearly displaying the name of “Assam Electricity Grid Corporation Limited” on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings. Also all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing: WARNING: THIS IS PROPRIETARY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH AEGCL. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM THE EMPLOYER IN WRITING.

3.4.5 While submitting the structural drawings, bill of materials and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing Bid Reference No., Name of the transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies. The Contractor shall be required to submit 15 copies of all relevant drawings for necessary distribution.

3.5.0 SLENDERNESS RATIO

3.5.1 ***Slenderness ratio for members shall be computed in accordance with Clause 10 of IS: 802. The limiting values of L/R shall be as follows:***

(a) Leg members, G.W. peak and cross arm lower member:	120
(b) Bracings:	200
(c) Redundant members and those carrying nominal stress:	250
(d) Tension member:	400

3.6.0 CONDUCTOR CONFIGURATION

3.6.1 In case of single circuit line the conductor shall be in triangular formation with one conductor on one side of the tower and the other two on the other side.

3.6.2 In case of the double circuit line (and also in case of single circuit line in double circuit towers with provision of stringing the line in future), the six power conductors shall be square type of formation at distances suiting to the specified clearance requirements. The lines will be placed on either side of the tower with the phase conductors of each line being placed vertically on above the other and as far as possible are equidistant from the centre line of the towers. One continuous earth wire shall be provided above the conductors at suitable distance to offer effective shielding and safe clearance.

3.7.0 HEIGHT AND LOCATION OF GROUND WIRES

3.7.1 Provision of single earth wire / ground wire shall be made in the design of the towers. The height and location of the ground wires will be such that the shield angle is not greater than 30 degrees.

3.7.2 The mid-span clearance between the earth wire and conductors shall be kept more than the clearance at the tower. The Contractor shall maintain the sag of the ground wire at least 10 percent less than that of the power conductor under all temperature conditions in still wind at the normal spans so as to give a mid-span separation greater than that at the supports.

3.8.0 LOADS ON TOWERS

3.8.1 The tower members shall be designed for three conditions of loadings. The conditions with their combinations of loadings are as follows:

A) ***Reliability Condition (Normal Condition)***
- i) Transverse Loads as per Clause: 3.8.2.
- ii) Vertical Loads as per Clause: 3.8.5.
- iii) Longitudinal Loads as per Clause: 3.8.8.

B) ***Security Condition (Broken wire condition)***
- i) Transverse Loads as per Clause: 3.8.3.
- ii) Vertical Loads as per Clause: 3.8.6.
- iii) Longitudinal Loads as per Clause: 3.8.9.

C) ***Safety Condition (Construction and Maintenance)***

a) *Normal Condition*
- i) Transverse Loads as per Clause: 3.8.4 (a).
- ii) Vertical Loads as per Clause: 3.8.7.
- iii) Longitudinal Loads as per Clause: 3.8.10 (A).

b) *Broken Wire Condition*
- i) Transverse Loads as per Clause: 3.8.4 (b).
- ii) Vertical Loads as per Clause: 3.8.7.
- iii) Longitudinal Loads as per Clause: 3.8.10 (B).

3.8.2 *Transverse Loads: Reliability Condition (Normal Condition)*

Under this following loads shall be taken into account:

a) **Wind Load on Conductor and Ground Wire**:
This shall be calculated by taking the basic wind pressure be acting normal to the line.

b) **Wind Load on Insulator String**:
Wind load on insulator strings shall be determined from the attachment point to the centre line of the conductor in case of suspension towers and upto the end of clamp in case of tension towers. The Design wind pressure shall be considered acting on 50% area of insulator string projected on a plan, which is parallel to the longitudinal axis of the string.

c) **Wind Load on Towers:**
This shall be calculated considering the wind to be acting normally on face of the tower.

d) **Transverses Loads from Mechanical Tension of Conductors and Ground Wire (Due to line deviation):**
This is the component of conductor/ground wire tension at tower acting in the transverse direction of the line. In calculating this force; the conductor/ground wire tension is either the tension at every day temperature (32^0 C) &100% of full wind pressure or the tension at minimum temperature and 36% of full wind pressure whichever is more.

3.8.3 *Transverse Loads: security condition*

a) Suspension Towers

i. Transverse loads due to wind acting on tower structure, conductors, ground wires and insulators shall be taken as nil.

ii. Transverse loads due to line deviation shall be based on component of mechanical tension of conductors and ground wires corresponding to everyday temperature and nil wind condition. For broken wire the component shall be corresponding to 75% of mechanical tension of conductor and 100% of mechanical tension of ground wire at every day temperature and nil wind.

b) Tension and Dead End Towers

i. Transverse loads due to wind action on tower structure, conductors, ground wire and insulators shall be as per Clause: 3.8.2 (a) and (b) 60% wind span shall be considered for broken wire and 100% for intact wires.

ii. Transverse loads due to line deviation shall be the component of 100% mechanical tension of conductor and ground wire as defined in Clause: 3.8.2 (d).

3.8.4 *Transverse Loads: safety condition*

a) Normal Condition: -- Suspension, Tension and dead End Tower

i) Transverse loads due to wind action on tower structure, conductors ground wires and insulators shall be taken as nil.

ii) Transverse loads due to mechanical tension of conductor or ground wire shall be calculated in same manner as in Clause: 3.8.2 (d) but with tension corresponding to everyday temperature and nil wind.

b) Broken Wire Condition: -- Suspension, Tension and dead End Tower

i) Transverse loads due to wind action on tower structure, conductors, ground wire, insulators shall be taken as nil.

ii) Transverse load due to mechanical tension of conductor or ground wire on account of line deviation shall be taken as follows:

$$TM = TI \times \sin \varphi/2, \text{ where,}$$

Where, TM = Load

TI = 50% of tension of conductor and 100% of tension of ground wire at everyday temperature and nil wind for suspension tower and 100% for angle and dead end towers for both conductor and ground wire.]

Φ = Angle of deviation of tower.

3.8.5 *Vertical Loads: Reliability Condition (normal condition)*

i) Loads due to weight of each conductor and ground based on appropriate weight span, weight of insulator strings and accessories.
ii) Self weight of structures up to tower panel under consideration.

3.8.6 *Vertical Loads: Security Condition*

i) Loads due to weight of each conductor or ground wire based on appropriate weight span, weight of insulator strings and accessories taking broken wire condition where the load due to weight of broken conductor/ground wire shall be considered as 60% of weight span. For intact wire the vertical load shall be considered as given in Clause: 3.8.5.
ii) Self weight of structures up to tower panel under consideration.

3.8.7 *Vertical Loads: Safety Condition*

i) *Same as Clause 3.8.6 (i) multiplied by overload factor of 2.0*
ii) Same **as Clause 3.8.6 (ii).**
iii) A load of 1500 N shall be considered acting at each cross arm tip as a provision for weight of line man with tools.
iv) An additional load of 3500 N at cross arm tip.
v) All bracings and redundant members of the towers which are horizontal or inclined upto 15^0 from horizontal shall be designed to withstand as ultimate vertical load of 1500 N considered as acting at centre, independent of all other loads.

3.8.8 *Longitudinal Loads: Reliability Condition*

A) *Suspension and Tension Towers*
   i) Longitudinal loads for Suspension and Tension towers shall be taken as nil.
   ii) Longitudinal loads which might be caused on tension towers by adjacent spans of unequal length shall be neglected.

B) *Dead End Tower*
   i) Longitudinal loads for Dead End Towers shall be considered corresponding to mechanical tension of conductors and ground wires at every day temperature & design wind pressure or at minimum temperature with 36% of design wind pressure, whichever is more stringent.

3.8.9 *Longitudinal Loads: Security Condition*

A) *Suspension Towers*
The longitudinal loads corresponding to 50% of the mechanical tension of conductor and 100% of mechanical tension of ground wire shall be considered under everyday temperature and no wind pressure for broken wire only.

B) *Tension Towers*
Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire shall be taken for loading criteria mentioned in Clause: 3.8.8 (B) for broken wires. For intact wires these loads shall be considered nil.

C) *Dead End Towers*
Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire shall be taken for loading criteria mentioned in Clause: 3.8.8 (B) for intact wires; however for broken wires these loads shall be considered nil.

3.8.10 *Longitudinal Loads: Safety Condition*

A) *Normal Condition*

i) Suspension and Tension Towers

These shall be taken as nil.

ii) *Dead End Towers*

These loads for Dead End towers shall be considered as corresponding to mechanical tension of conductors/ground wire at every day temperature and nil wind. Longitudinal loads due to unequal spans may be neglected.

B) *Broken wire Condition*

i) Longitudinal loads during construction simulating broken wire condition will be based on stringing of one earth wire or one complete phase conductor at one time.

ii) *Suspension Towers*

Longitudinal loads during stringing on suspension towers should be normally imposed only by the passing restriction imposed during pushing of the running block through the sheave. It will apply only on one complete phase of sub-conductor or one earth wire. It will be taken as 10000 N per sub-conductor or 5000 N per earth wire.

iii) *Tension and Dead End Tower*

Angle Towers used as dead end during stringing simulating broken wire condition shall be capable of resisting longitudinal loads resulting from load equal to twice the sagging tension (sagging tension is 50% of the tension at every day temperature and nil wind) for one earth wire or one complete phase sub-conductors which is in process of stringing. At other earth wire or conductor attachment points for which stringing has been completed, loads equal to 1.5 times the sagging tension will be considered.

3.8.11 *Anti Cascading Checks*

i) All angle towers shall be checked for the following anti-cascading conditions with all conductors and G.W. intact only on one side of the tower.

ii) *Transverse Loads:-* These loads shall be taken under no wind condition.

iii) *Vertical Loads:-* These loads shall; be the weight of conductor/ground wire intact on one side of tower, weight of insulator strings and accessories.

iv) *Longitudinal Loads:-* These Loads shall be the pull of conductor/ground wire at every day temperature and no wind applied simultaneously at all points on one side with zero degree line deviation.

3.8.12 *Broken Wire Conditions*

A) ***SINGLE CIRCUIT TOWERS***

Any one-phase conductor or earth wire broken, whichever is more stringent for a particular member.

B) ***DOUBLECIRCUITTOWERS***

i) *SUSPENSIONTOWERS*

Any one phase conductor or earth wire broken, whichever is more stringent for a particular member.

ii) *ANGLETOWERS, TYPE-B & C*

Any two phases broken on the same side and same span or any one phase and one ground wire broken on the same side and same span whichever combination is more stringent for a particular member.

ii) *ANGLETOWERS, TYPE-D (Dead End Tower)*
Any three phases broken on the same side and same span or any two phases and one ground wire broke on the same side and same span whichever combination is more stringent for a particular member.

3.9.0 DESIGN WIND PRESSURE

3.9.1 Design Wind Pressure for the purpose of this Specification shall be taken as **720 N/m²** which corresponds to wind velocity at 10 m height. For Design Wind Pressure at other heights reference shall be made to ***IS: 802 or 'Transmission Line Manual'*** published by Central Board of Irrigation and Power, *New Delhi.* The Design Wind Pressure mentioned above is corresponds to Wind Zone-5, Reliability Level-1 and Terrain Category-2 as per IS: 802.

3.10.0 OTHER DESIGN PARAMETERS

3.10.1 For other design parameters to be adopted for the design of towers reference shall be made to ***Clause – 1.6, Section - 1*** of this Specification.

3.11.0 MATERIALS

3.11.1 Tower Steel Sections

3.11.1.1 Steel Sections of tested quality of conformity with IS:2062 (Designated Y.S. 250 MPa) or/and IS:8500 (Designated Y.S. 350 Mpa) or equivalent international standards are to be used in towers, extensions and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards. However, use of steel grade having designated yield strength more than that of EN 10025/BS-4360-50B grade (355MPa) is not permissible.

3.11.1.2 Steel plates below 6 mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (Grade -0) or equivalent international standards are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS: 2062 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to Fe-410 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. The chequered plates shall conform to IS: 3502 or equivalent international standards.

3.11.1.3 For designing of towers, preferably rationalized steel sections have been used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost *to* Employer and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer before any substitution.

3.11.2 Fasteners: Bolts, Nuts and Washers

3.11.2.1 All bolts and nuts shall conform *to* IS-12427or equivalent international standards. All bolts and nuts shall be galvanized as per IS: 1367 (Part-13)/18:2629or equivalent international standards and 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.

3.11.2.2 The bolt shall be of 16/24 mm diameter and of property class 5.6 as specified in IS: 1367 (Part-III)or equivalent international standards and matching nut of property class 5.0 as specified in IS: 1367: (Part-VI)or equivalent international standards.

3.11.2.3 Bolts upto M 16 and having length upto 10 times the diameter if 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 31 0 MPa minimum as per IS: 12427or equivalent international standards. Bolts should be provided with washer face in accordance with 1S:1363 (Part-I)or equivalent international standards *to* ensure proper bearing.

3.11.2.4 Nuts should be double chamfered as per the requirement of IS: 1363 Part-II'. It should be ensured by the manufacturer that nuts should not be overlapped beyond 0.4MM oversize on effective diameter *for* size upto M 16.

3.11.2.5 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.

3.11.2.6 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 not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.

3.11.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electro galvanised, positive lock type and 3.5mm in thickness *for* 16mm dia bolt and 4.5mm *for* 24mm bolt.

3.11.2.8 *To* avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness *of* members more than three (3) times its diameter.

3.11.2.9 The bolt positions in assembled towers shall be as per structural drawing.

3.11.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.

3.11.2.11 *To* ensure effective in-process Quality control it is essential that the manufacturer should have in house testing facility *for* all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this Specification and ISO: 14000 series Quality System Standard

3.12.0 TOWER ACCESSORIES

3.12.1 Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.

3.12.2 Step Bolts & Ladders

3.12.2.1 Each tower shall be provided with step bolts conforming to IS: 10238or equivalent International Standards of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. The step bolt shall be fixed-on one leg upto waist level and on two diagonally opposite legs above waist level upto top of the towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of with standing a vertical load not less than 1.5 KN.

3.12.2.2 For special towers, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be provided. Suitable platform using 6mmthick perforated chequered plates along with suitable railing for access from step bolts to the ladder and from the ladder to each cross arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.

3.12.3 Insulator Strings and Earth wire Clamps Attachments

3.12.3.1 Single / Double suspension insulator string assemblies shall be used for 'A' type tower as required. For the attachment of Suspension Insulator string, a suitable strain plate of sufficient

thickness for transferring the load to the tower body shall be provided. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the 1nsulator string the insulator string the same shall be supplied by the Contractor.

3.12.3.2 At tension towers strain plates of suitable dimensions placed on the underside of each cross-arm tip, shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the attachments shall be provided to the successful bidder. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

3.12.3.3 All important crossing like Railway Tracks, Important Roads, Rivers or any other Crossings of similar nature shall be done with Double Insulator String.

3.12.4 OPGW Clamps Attachment

3.12.4.1 Suspension Clamp

The detailed drawing shall be submitted by the Contractor for Employer's approval. The Contractor shall also supply U- bolts, D-shackles wherever required.

3.12.4.2 Tension Clamps

OPGW peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Employer's approval for details of the attachments before the mass fabrication.

3.12.5 Anti-climbing Device

Barbed wire type anti climbing device, as per IS 5613or equivalent International Standards shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS-278 (size designation A 1)or equivalent International Standards. The barbed wires shall be given chromatin dip as per procedure laid down in IS: 1340or equivalent International Standards.

3.12.6 Danger, Number and Phase plate

Danger Plates, Number plates and phase plates shall be provided and installed by the Contractor.

a) Each tower shall be fitted with a danger plate, number plate and a set of phase plates. The transposition tower should have the provision of fixing phase plates on both the transverse phases.

b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS-2551or equivalent International Standards and shall be in a signal red on the front of the plate.

c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.

d) The letters of number and circuit plates shall be red enamelled with white enamelled background.

3.12.7 Aviation Requirements

Aviation requirements, if indicated separately in Schedule of Requirements shall be in the scope of the Contractor and the same shall conform to IS: 5613 or equivalent International Standards.

3.13.0 TOWER FABRICATION

3.13.1 The fabrication of towers shall be in conformity with the following:

3.13.1.1 Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

3.13.1.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

3.13.1.3 No angle member shall have the two leg flanges brought together by closing the angle.

3.13.1.4 The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

3.13.1.5 The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

3.13.1.6 All identical parts shall be made strictly inter-changeable. All steel sections before any work are done on them shall be carefully levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

3.13.1.7 **Minimum Thickness of Tower Members:**

The minimum thickness of galvanised and painted tower members shall be as follows: -

ITEM	Minimum thickness in mm	
	Galvanised	Painted
Leg members & lower members of cross arms in compression	5	6
Other members	5	5

3.13.1.8 No tower angle member shall be less than 45x45x5 mm

3.13.2 **Drilling and Punching**

3.13.2.1 Before any cutting work is started, all steel sections shall be carefully strengthened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

3.13.2.2 Holes for bolts shall be' drilled or punched with a jig but drilled holes shall he preferred. The punching may be adopted for thickness upto 16mm. Tolerances regarding punch holes are as follows:

a) Holes must be perfectly circular and no tolerances in this respect are permissible.
b) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched holes should not exceed 0.8 mm on diameter.
c) Holes must be square with the plates or angles and have their walls parallel.

3.13.2.3 All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

3.13.3 **Erection mark**

3.13.3.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark shall be marked with marking dies of 16mm size before galvanizing and shall be legible after galvanizing,

3.13.3.2 Erection Mark shall be A-BB-CC-DDD

A = Employer's code assigned to the Contractors -Alphabet
BB = Contractor's Mark-Numerical
CC = Tower Type Alphabet.
DDD= Number mark tube assigned by Contractor -Numerical.

3.14.0 QUANTITIES AND WEIGHTS

3.14.1 The quantities of the following items have been envisaged in Metric Tonne (MT) in the relevant price Schedules for various types of towers:

i) Basic Body.
ii) Body Extensions.
iii) Stubs & Cleats
iv) Bolts & Nuts including spring washers and step bolts etc.

During detail engineering, proto assembly of each of the above items shall be inspected, tested and approved by AEGCL and subsequently shall be released for fabrication and manufacturing as per the Technical Specification by the Contractor.

3.15.0 WEIGHTS OF TOWER

3.15.1 The weight of tower, stubs and stub template for payment purposes shall mean the weight, calculated by using the standard sectional weights (as per relevant IS) of all steel members 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 galvanizing /painting. Similar method shall be used for nuts & bolts also.

3.15.2 The weight of various types structures indicated in the Bill of Materials (Annexure-I & II of Section-1) are provisional only and for bidding purpose. Payments shall be made on the basis of drawings released for construction.

3.16.1

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3.17.0 GALVANIZING AND PAINTING

3.17.1 Galvanising and painting of the various members of the structures shall be done only after all works of sawing, shearing, drilling, filing, bending and matching are completed. Galvanising shall be done by the hot dip process as recommended in IS: 2629 or other such authoritative international standards and shall produce a smooth, clean and uniform coating of not less than 610 gm per square meter. The preparation for galvanising and the galvanising process itself must not affect adversely the mechanical properties of the treated materials.

3.17.2 All assembly bolts shall be thoroughly hot dip galvanized after threading. Threads shall be of a depth sufficient to allow for the galvanized coating, which must not be excessive at the root of the threads, so that the nut shall turn easily on the completed bolts without excessive looseness. The nut threads shall not be galvanized, but oiled only.

3.17.3 The outside surface shall be galvanised. Sample of galvanised materials shall be supplied to the galvanising test set out in IS 729 or other such authoritative international standards.

3.17.4 The portion of the stub angle from 150 mm below the plinth level shall be black and the remaining portion shall be galvanised.

3.17.5 The parts, which are to be painted, shall be thoroughly cleaned. Two coats of a good quality primer shall be applied to produce a smooth void less surface before applying one coat of approved quality aluminium paint at works. The final coating of aluminium paint shall be applied after erection at site.

3.18.0 EARTHING

3.18.1 To keep provision in the towers for earthing, two holes of 17.5 mm diameter and about 50 mm apart shall be drilled on each of the legs of the towers, such that the lower hole is about 350 mm above the ground level, clear of the concrete muffing, for connecting the earthing strip.

3.19.0 TEST AND TEST CERTIFICATE

3.19.1 Each consignment ready for transportation shall be offered to the Employer for inspection before dispatch. Samples of fabricated tower materials shall be subjected to following tests: -

a. Tower steel: The structural steel shall conform to IS 226 and IS 8500 or other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.
b. Galvanising: The galvanising shall be as per IS 2633 or other such authoritative international standards. Zinc coating over the galvanised surfaces shall not be less than 610 gm per square meter.
c. Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

3.19.2 *Test at Contractor's Premise:*

The contractor shall fabricate one specimen tower of each type as soon as possible after placement of order and before starting the bulk fabrication of the towers ordered. It shall be assembled on a foundation as nearly similar as practicable to site and tested with suitable test loads as per specified broken wire condition, multiplied by the corresponding factor of safety to ensure that the design and fabrication complies with the requirements. Each structure shall be capable of withstanding the above-mentioned tests without any injury or any permanent deflection at any part. If any member is found to be weak or damaged the design should be suitably modified and the tower re-tested.

After manufacture of first lot, finished members forming each type of towers shall be selected at random and tested for quality. The tower then shall be set on foundation as nearly similar as practicable to site and tested with equivalent test load for which the tower has been designed.

No tower or any member thereof, which failed under the test shall be supplied. No tests need to be carried out on the special towers and the 3 meter and 6 meter extensions. As such, they shall be very carefully designed on the basis of the results of the other types of towers.

If desired by the Employer, towers shall be tested to destruction at the expenses of the contractor/supplier. The Employer reserves the right to witness any and all of the tests carried out as above and so should be given 30 days advance notice of the dates on which such tests are scheduled to be carried out.

3.20.0 LIST OF STANDARDS AND GUIDES

3.20.1 List of Indian Standards and other related Publications:

Sl. No	Indian Standards	Title
1	IS: 209-1992	Specification for Zinc
2	IS 278-1991	Galvanised Steel Barbed wire
3	IS 800-1991	Code of Practice for Steel in General Building Construction.
4	IS: 802 (Part1, 2,3)	Code of Practice for use of Steel in Overhead Transmission Line
5	IS: 808-1991	Dimensions for Hot Rolled
6	IS: 875-1992	Coe of Practice for Design Loads

Sl. No	Indian Standards	Title
		(other than Earthquakes) for Buildings and Structures
7	IS: 1363-1990	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures
8	IS: 1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners
9	IS: 1477-1990	Code of practice for Painting of Ferrous Metals in Buildings
10	IS: 1573-199	Electro-Plated Coatings of zinc on iron and Steel
11	IS: 1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products
12	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures
13	IS: 2016-1992	Plain Washers ISO/R887
14	IS:2062-1992	Steel for general structural purposes
15	IS: 2074-1992	Ready Mixed Paint. Air Drying Red Oxide, Zinc Chrome, Red Oxide, Zinc Chrome Priming Specification
16	IS:2551-1990	Danger Notice Plates
17	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel
18	IS: 2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles
19	IS: 3043-1991	Code of Practice for Earthing
20	IS: 3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws
21	IS:3757-1992	High Strength Structural Bolts
22	IS: 4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products
23	IS: 5369-1991	General Requirements for Plain Washers
24	IS:5613-1993	Code of Practice for Design installation and Maintenance of overhead Power Lines
25	IS:6610-1991	Specification for Heavy Washers for Steel structures
26	IS: 6623-1992	High Strength Structural Nuts
27	IS: 6639-1990	Hexagon Bolts for Steel Structure
28	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles
29	IS: 8500-1992	Specification for Wieldable Structural Steel (Medium & High Strength Qualities)
29	IS: 10238-1989	Step Bolts for Steel Structures
30	IS: 12427-1988	Bolts for transmission Line Towers
31		Indian Electricity Rules
32	Publication No.19 (N)700	Regulation for Electrical Crossing of Railway Tracks
33	CBIP Publication No-	Transmission Line Manual

SECTION-4

TOWER FOUNDATIONS

(TECHNICAL SPECIFICATIONS)

4.1.0 SCOPE

4.1.1 This section covers the specifications for design of foundations for various types of towers and special structures under different soil condition described herein after.

4.1.2 Design of foundations is not in the scope of Bidders for this package. The foundations shall be constructed on the basis of drawings supplied by the Employer. However, in case any special type of foundation is required but is not covered in the bidding document, the Employer may ask the Contractor to design and construct such foundation.

4.2.0 STANDARDS

4.2.1 For design of foundations reference shall be made to ***IS 4099.*** Reference shall also be made to '***Transmission Line Manual'*** issued by *Central Board of Irrigation and Power, New Delhi.*

4.3.0 TYPE OF FOUNDATION(To be provided by AEGCL)

4.3.1 Most of the paddy fields of Assam remain under water for about 3 months in a year. During the remaining period of the year sub-soil water is normally found about 1.5 meters below the ground level. The Contractor shall note this factor while designing the foundation of towers.

4.3.2 It is expected that the type of foundations defined in **Clause 4.3.4** below shall be suitable for use at various locations of all the Transmission Lines covered in this Bid Document. *The Contractor shall examine the suitability of foundation type assigned for each location depending on the soil investigation reports.*

4.3.3 In case a defined type of foundations cannot be used at certain location(s), the Contractor may be asked to design foundations for such locations and payments shall be made at unit rates of other type of foundations.

4.3.4 The Contractor shall design and quote for the following four types of foundations and all the foundations shall be RCC type.

(i) ***Dry type foundation***:Design of this type of foundation shall be normally for dry / rocky / hard soil for which, (a) weight of earth shall be assumed to be 1600 kg/cum. (b) The Limit Bearing Capacity of the soil shall be 22000 kg/square meter. (c) The angle of repose shall be 30°.

(ii) ***Wet type foundation (Suitable for paddy field location):*** Design of this type of foundation shall be for locations where sub-soil water level is found below 1.5 meters from the ground level. This design shall also be suitable for paddy fields in Assam, as described in the first Para 4.3.1 above. The weight, the limit bearing capacity, the angle of repose and the ultimate bearing capacity of soil up to depth of 1.5 meter shall be taken as mentioned in (i) above and same for earth beyond 1.5 meter depth shall be taken as per (iv) below.

(iii) ***Semi sub-merged type foundation***: Design of this type of foundations shall be for locations where sub-soil water level is found below 0.75 meter from the ground level.

The weight, the limit bearing capacity, the angle of repose and the ultimate bearing capacity of soil up to depth of 0.75 meter shall be taken as mentioned in (i) above and same for earth beyond 0.75 meter depth shall be taken as per (iv) below.

(iv) ***Sub-merged type foundation***: Design of this type of foundations shall be for locations where sub-soil water level is found at less than 0.75 meter from the ground level including completely sub-merged locations. (a) The weight of earth shall be assumed to be 850 kg/cum. (b) The limit bearing capacity of the soil shall be 11000 kg/sq. meter. (c) The angle of repose shall be 15°.

(v) **Special Foundation:** Short Pile/Caisson/Pile drawings to be provided by AEGCL.

4.4.0 SEISMIC CONDITION:

4.4.1 Each foundation shall be provided with the tie beam for each type of tower to take care of seismic conditions. Force due to earthquake shall be assumed to be vertical 0.1g and horizontal 0.2g.

4.5.0 OVER LOAD FACTOR

4.5.1 The magnitude of limit loads for foundation should be taken as 10% higher than those for the corresponding towers.

4.6.0 FOUNDATION DEPTH

4.6.1 The total depth of foundations below the ground level shall not be less than 1.5 meter. To maintain inter-changeability of stubs for all type foundations of each type of towers almost the same depths of foundations will be used. However, the maximum depth of foundations for all types of towers shall not be more than 3.0 meters below the ground level.

4.7.0 LOADS ON FOUNDATIONS

4.7.1 The foundation shall be designed to withstand the loads of the superstructure (as specified under Section -3) for the full footing reactions obtained form the structure as per analysis in conformity with the relevant factors of safety. The reactions on the footings shall be composed of the following types of loads for which they shall be required to be checked.

1. Maximum tension or uplift
2. Maximum compression of down thrust
3. Maximum horizontal shear or side thrust

4.7.2 The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and the embedded steel parts will also be taken into account adding to the down thrust.

4.8.0 CONCRETING

4.8.1 The concrete foundation for transmission line towers shall consists of two portions viz. (i) pyramid & (ii) chimney. In chimney portion, the thickness of the concrete cover should be such that it provides minimum cover of not less than 10 cm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations, limiting the minimum section of chimney to 30.5 cm. Sq. In respect of all wet locations, the section of chimney should be 45.72 cm. Sq. uniformly for all sizes of stub angle.

4.8.2 The chimney top or muffing must be 23 cm above ground level in dry locations, 38 cm in irrigated field and 15.24 cm above maximum water level in tank beds.

4.8.3 The size of the bottom portion of the foundation viz. Pyramid should be designed according to the nature of the sub soil met with at the design depth for the stub angles.

4.8.4 The maximum base thickness in the pyramid portion in case of sub-merged foundation may be taken as 200 mm.

4.9.0 VOLUME OF FOUNDATIONS

4.9.1 The volume of foundation of a tower shall mean the total volume of the foundation including chimney, tie beams and the PCC soling. The volumes indicated for various types of tower foundations in BOQ provided are provisional only and for bidding purpose. Measurements and payments shall be made only on the basis drawings released for construction.

SECTION- 5

ERECTION OF TRANSMISSION LINE

(TECHNICAL SPECIFICATIONS)

5.1.0 SCOPE

5.1.1 This section covers the construction of the foundation as per approved drawing of the Employer, erection of towers and stringing of conductors and ground wires i.e. the complete construction of the proposed line.

5.2.0 SCOPE OF THE CONTRACT

5.2.1 The contractor will be responsible for all materials on turnkey basis and complete erection to the satisfaction of the Employer till the time of taking over of the transmission lines by the Employer.

5.3.0 SURVEY

5.3.1 The contractor shall execute both the detailed and check survey of the entire route selected by the Employ as far as possible. For this, the contractor will be supplied with the data of the original reconnaissance survey.

5.3.2 During the survey the contractor shall check the original reconnaissance survey and make recommendations for change if found necessary according to the final design of towers and shall make fresh profile sheets and submit the same for approval of the Employer before commencement of construction works.

5.3.3 During the Check Survey the Contractor shall also conduct soil investigation to decide on the type of the foundation to be adopted at various locations.

5.4.0 RIGHT OF WAY

5.4.1 The Employer will arrange for the right of way but clearance of jungles etc if necessary will have to be done by the contractor.

5.5.0 FOUNDATION CONSTRUCTION

5.5.1 For normal concrete foundation and for any other special foundation, the tenderer shall obtain approval of complete design for each of the foundation proposed to be adopted in different types of soil conditions. He will be responsible for construction of the foundations in accordance with the approved design. The Contractor shall be responsible for each foundation and shall be responsible for any failure, which in the opinion of the Employer is due to insufficient care having been taken either in investigation of sub-soil conditions or defective erection.

5.5.2 The work shall include all necessary revetment, concreting and earth filling above ground level. The concrete on stubs shall be set with the tops above 380 mm above ground level. Where the ground surface is irregular, the foundation will be finished off in a suitable and permanent way by forming a plinth by side cutting, building a suitable revetment as desired by authorised representative of the Employer.

5.5.3 The back fill material should be clean and free of organic or other foreign materials. The back fill shall be compacted with special care. The back fill shall be deposited in layers having a

thickness of not more than 200 mm after compression. The back filling operation shall be such that the materials when compressed will be blended sufficiently to secure the best practicable degree of compaction. The back filling and grading shall be carried to an elevation of approximately 75 mm above the finished ground level to drain out water.

5.5.4 The detailed specifications of the concrete foundation and the method of concreting will be required to be submitted to the Employer and approval obtained prior to commencement of work.

5.5.5 All wet foundations must be kept completely de-watered both during the placing of the concrete and for two hours subsequent to completion.

5.5.6 The concrete shall be covered by gunny bags being kept wet for a period of 24 days after laying. The pits may be back filled with wetted earth and consolidated for a minimum of 24 hours and thereafter the exposed top and fill shall be kept for the prescribed time of 21 days.

5.6.0 ERECTION OF TOWERS

5.6.1 The method will be left to the Contractor subject to the responsibility for any damage done to the materials due to any cause.

5.6.2 The towers must be truly vertical after erection and no straining will be permitted to bring them to a vertical position. Tolerance limit for vertical shall be one in 360 of the tower height. All nuts shall be tightened properly. Before tightening it is ensured that filler washers and plates are placed in relevant gaps between members, bolts of proper size and length are inspected and one spring washer is inserted under each nut. The tightening shall be progressively carried on from the top downwards, care being taken that all bolts at every level are tightened simultaneously.

5.6.3 The threads of bolts projecting outside 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.

5.6.4 The Contractor shall arrange for tack welding of all nuts and bolts up to the bottom cross arm level of the towers, if so desired by the Employer. So, the Contractor shall quote separately for such tack welding for each type of tower on per tower basis. The quoted rates for erection of towers shall, therefore, be exclusive of the cost of above tack welding.

5.7.0 STRINGING OF CONDUCTOR AND OPGW

5.7.1 The stringing of the conductors and earth-wires shall be done in a most standard method used for such lines, which shall be indicated in the tender. The Contractor shall give complete details of the stringing method they propose to follow and indicate its adaptability and advantages. They shall also indicate the tools and equipment required for stringing by the method proposed by them. The contractor shall use his own stringing and erection tools and other equipment.

5.7.2 The contractor shall be entirely responsible for any damage to the towers or the conductors during stringing.

5.8.0 HANDLING OF CONDUCTOR

5.8.1 The contractor shall be entirely responsible for proper handling of the conductor, earth wire and accessories in the field. Care shall be taken to ensure that the conductor is not damaged; the section affected shall be replaced or repaired by putting joint or using repair sleeves or polishing with emery cloth, so as to give satisfactory performance.

5.9.0 PULLING ON OPERATION

5.9.1 The OPGW shall be strung and securely clamped to the towers before the conductors are drawn up in order of the top conductor first.

5.9.2 The pulling of the conductor into the travellers (comprising of aerial and ground rollers) shall be carried out in such a manner that the conductor is not damaged or contaminated with any foreign substance and that it may not be rubbed with rough ground surface. The traveller surface in contact with aluminium surface of conductor is not damaged. These shall be equipped with high quality ball and roller bearings for minimum friction.

During pulling out operation the tension in each conductor and OPGW shall not exceed the design working tension of the conductor at the actual prevailing temperature. After being pulled the conductor and the earth wire shall not be allowed to hang in the stringing blocks for more than 96 hours, before being pulled to the specified sag. It shall be ensured that the conductors and earth wire are not damaged due to wind, vibration or other cause.

5.10.0 SAGGING IN OPERATION

5.10.1 The conductors shall be pulled up to desired sag and left in travellers for at least one hour after which the sag shall be rechecked and adjusted. The conductors shall be clamped within 36 hours for sagging in. The sags shall also be checked when the conductors have been drawn up and transferred to the insulator clamps.

5.10.2 At sharp vertical angles the sags and tensions shall be checked on both sides of the angle. Sagging operations shall not be carried out under wind, extremely low temperature or other adverse weather conditions, which prevent satisfactory sagging.

5.11.0 JOINTING

5.11.1 All the joints of the conductor or the earth wire shall be compression type in accordance with the recommendations of the manufacturers, for which the necessary tools and equipment like compressors and dies, grease guns, presses shall have to be arranged by the contractor.

5.11.2 All joints and splices shall be made at least 30 meters away from the structures. No joint or splices shall be made in span crossing over main roads, railways, small rivers or in tension spans. Not more than one joint shall be allowed in one span.

5.11.3 After pressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

5.12.0 INSULATOR HOISTING

5.12.1 Suspension insulators shall be used up to deviation of 2 degrees on all ‘A’ type towers in the line and strain insulators on all ‘B’, ‘C’ and ‘D’ type towers. Except on approaching towers, all suspension strings will consist of the specified number of insulator discs per string with arching horns on line side only and tension string of specified number of insulator discs per string with arcing horns on both line and tower sides.

5.12.2 Insulator strings shall be assembled on the ground. These shall be cleaned and examined before hoisting. Insulators with hair cracks or clips or those having glazing defects exceeding half centimetre square will not be used. No separate rates shall be quoted for insulator hoisting. The charges shall be included in the rates of string of conductors.

5.13.0 ACCESSORIES

5.13.1 Accessories like vibration dampers; armour rods etc. for the conductor shall also be fitted on the line. Armour rods shall be provided at all suspension support of the conductors and vibration dampers shall be provided at both ends of each span at suitable distances from the supporting points for each phase conductor. All accessories shall be clean, smooth and in perfect condition before fitting.

5.14.0 STRINGING RATE

5.14.1 The rate of stringing of the conductors and earth wire per kilometre route length of line will include laying, stringing, tensioning, clamping and jointing of these power conductors, one earth wire and fitting of all necessary accessories above or otherwise, which are normally required or are usual with such lines.

5.15.0 GROUNDING

5.15.1 The Contractor shall measure the tower footing resistance of each tower after it has been erected and before the stringing of the OPGW during dry weather. Each tower shall be earthed and the tower footing resistance shall not exceed 10 ohms. Generally pipe type earthing shall be done in accordance with the latest additions and revisions of:

IS: 3043 : Code of practice for Earthing or equivalent International Standards.

IS:5613 :Code of practice for Design, Installation and maintenance(Part-II/Section-2) of overhead power linesor equivalent International Standards.

No extra charges shall be admissible for these tests.

5.15.2 The earthing will be effected by burying 3 meters long GI pipe in a 300 mm diameter and 3750 mm deep pit at a distance of not less than 3650 mm diagonally away from the stubs and filling in the pit with finely broken coke having the granule sizes not less than 25 mm and salt in such a way that a minimum cover of 125 mm thick salt mixed coke shall be maintained from the pipe on all sides and that the top edge of the pipe shall be at least 600 mm below the ground level. A 45 X 6 mm-galvanised steel flat shall be used to connect the tower with the pipe. The galvanising steel strip shall be buried not less than 600 mm deep from the ground level. The tenderer will quote the erection charges for each earthing inclusive of the cost of coke and salt, excavation and back filling etc.

5.16.0 FINAL CHECKING, TESTING & COMMISSIONING

5.16.1 After completion of the works, final checking of the line shall be done by the contractor to ensure that all the foundation work; 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 the following main points:

1. Sufficient back filled earth is layed over each foundation pit and it is adequately compacted.
2. Concrete chimneys and their copings are in good and finally shaped condition.
3. All the tower members are correctly used strictly according to final approved drawings are free of any defect or damage whatsoever.
4. All the bolts are fully tightened and they are properly punched.
5. The stringing of the conductors and earth wire done to maintain proper sag.

The contractor shall submit a report to the above effect. After final checking the line shall be tested for insulation and any defect found as a result of such test, the contractor shall rectify.

In addition to the above, the contractor shall arrange for testing of the total and relative sags of the conductors and earth wire and shall be responsible to maintain the values within specified tolerances.

The contractor shall make all arrangements for such tests and the contractor shall provide necessary labour, transport and equipment.

After satisfactory tests on the line and on approval by the Employer the line shall be energised at full operating voltage before handing over.

SECTION -6

TECHNICAL SPECIFICATIONS
INSULATORS & HARDWARE

6.3.0 SCOPE

6.3.1 This Section of the specification covers design, manufacture, testing at works of suspension and tension string insulator assemblies for 132 kV transmission lines.

6.4.0 STANDARDS

6.4.1 The suspension and tension string assemblies, insulator discs and hardware offered, material and processes adopted in the manufacture of insulator discs and hardware shall conform to the provision of the following Indian Standards or equivalent other international standards:

(1) IS: 731 Specification of porcelain insulators for overhead power lines.
(2) IS: 2486 Specification of insulator fittings for overhead power lines.
(3) IS: 2026 Specification for recommended practice for hot dip galvanising of steel
(4) IS: 2633 Specification for method for testing uniformity of coating on zinc coated articles.
(5) IS: 2107 Specification for white hearth malleable iron castings.
(6) IS: 2108 Specification for black hearth malleable iron castings.

6.5.0 INSULATOR AND STRINGS

The insulators of the strings shall consist of disc insulators with normal sheds for a three phase, 50 Hz, effectively earthed 132 kV transmission system in a lightly polluted atmosphere. Insulators shall be long rod type with Ball and socket connections.

6.3.1 Insulators shall 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.

6.3.2 Supplier quoting for long rod insulators made of electro porcelain shall also supply intermediate ball pins and intermediate arcing horns along with long rod insulators.

The price of these items shall be considered as including in the price of long rod insulators.

6.3.4 The size disc 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 :

Ball and Socket Designation

The dimensions of the balls and socket shall be of following designation for different for disc insulators in accordance with the standard dimensions stated in IS 2486-(Part-II)/IEC:120:-

Sl. No.	Rating of Insulators	Designation of Ball & socket as per IEC: 120
i)	70 KN	16 mm, AltB

ii)	90 KN	16 mm, AltB
iii)	120 KN	20 mm
iv)	160 KN	20 mm

2.4 **Dimensional Tolerance**

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

± (0.04 d + 1.5) mm when d < 300 mm.

± (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.

2.5 Intermediate Ball Pin Designation

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

2.6 Intermediate Arcing Horn

2.6.1 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 as shown in the specification shall also be provided.

The total effective arcing distance shall be 3050 mm for 400 kV line, 1800 mm for 220 kV line and 1200 for 132 kV line under nominal dimensions of insulator.

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

2.7 **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.

2.8 **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.

2.9 **Maintenance**

2.9.1 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.

2.9.2 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.

2.10 **Materials**

2.10.1 **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.

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

4.2 The Bidder shall furnish along with the bid the outline drawing (6 copies) of each insulator unit including a cross sectional view of the insulator shell. The drawing shall include but not limited to the following information:

(a) Shell diameter and ball to ball spacing with manufacturing tolerances

(b) Minimum Creepage distance with positive tolerance

(c) Protected creepage distance

(d) Eccentricity of the disc

(i) Axial run out

(ii) Radial run out

(e) Unit mechanical and electrical characteristics

(f) Size and weight of ball and socket parts

(g) Weight of unit insulator disc/long rod units

(h) Materials

(i) Identification mark

(j) Manufacturer's catalogue number

6.6.0 INSULATOR DISCS AND STRINGS

6.6.1 *TYPE OF INSULATORS:*

All suspension and tension strings shall consist of standard 255 x 145 mm centre ball and socket type porcelain insulators with all the exposed porcelain parts fully glazed, unless otherwise specified.

6.6.2 *QUALITY AND STRENGTH OF THE INSULATORS:*

The insulators and their hard wares used in the lines shall comply with requirement of relevant IS or other equivalent international standards. The pin-ball shackle diameter of suspension string will be 16 mm and tension string will be 20 / 16 mm. Minimum failing load shall be as per Clause-1.6, Section-1 of this Volume.

6.6.3 *MATERIALS USED*

The porcelain used in the manufacture of the insulators shall be of the best quality and shall be manufactured by the wet process. It shall be homogeneous, free from lamination; flaws etc. and well finished making it impervious to moisture. The glaze shall be brown colour and shall cover all the porcelain parts of the insulator except these areas necessarily left unglazed for the purpose of assembly. The cement used in the construction of the insulators shall not cause fracture by expansion or loosening and shall not give rise to any chemical reaction with the metal fittings.

6.7.0 INSULATOR STRING HARDWARE

6.7.1 *HARDWARE*

Each insulator string assembly shall generally include the following hardware:

Anchor shackle for attachment of suspension string assembly to the tower hanger and tension string assembly to the tower strain plate. Suitable top and bottom yoke assemblies with the arrangement of fixing a set of arcing horns.

- Set of arcing horns
- Suspension or tension clamp
- Bolts, nuts, washers, split pins etc.
- Other fitting s necessary to make the strings complete such as ball clevis, socket clevis, chain links etc.

The tenderer shall be responsible and satisfy himself that all the hardware included in strings are entirely suitable for the conductor offered.

6.7.2 *SUSPENSION CLAMP*

The suspension clamps shall be made of malleable iron or aluminium alloy, hot dip galvanised and shall be suitable to accommodate the conductor together with one set of preformed armour rods. Suitable sheet aluminium liners shall be provided. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor. The lips shall be rounded off and the seating and the bell mouths shall be smooth to avoid corona and radio interference noises. The suspension clamps shall be suitable to carry the bottom part of the arcing horn and to receive the fittings of the insulator string.

The suspension clamps shall be such that the conductor should not slip at a load of 25% of the breaking load of the conductor. The ultimate strength of the clamp for vertical load shall not be less than the failing load of the Disc Insulators.

6.7.3 *STRAIN CLAMP*

The bolted strain clamps shall also be made of malleable iron or aluminium alloy; hot dip galvanised, lined with sheet aluminium liners and shall be suitable to accommodate the conductor with necessary binding tapes etc. The lips shall be rounded off carefully and conductor seating and the ball mouth shall be smooth to avoid corona and radio interference noises. Suitable attachment for receiving one side of arcing horns and for connecting to the insulator strings shall be provided.

The strain clamps shall be such that the conductor should not slip at a load of 90% of the breaking load of the conductor. The ultimate strength of the clamp for horizontal load shall not be less than the ultimate strength of the conductor

6.7.4 *ARCING HORNS*:

Arcing horns of approved size and dimensions shall be provided for every string of insulators. The performance data for arcing horns to be supplied shall be made available to the Employer.

6.7.5 *OTHER INSULATOR STRING HARDWARE*:

The strength of other string hardware namely anchor shackle, yoke plates, socket-clevis etc. shall be co-ordinated with insulator disc strength.

Interchangability

The hardware together with ball and socket fittings shall be of standard design, so that this hardware are interchangeable with each other and suitable for use with disc insulators of any make con1orming to relevant Indian/International Standard

Ball and Socket Designation

The dimensions of the ball and socket shall be of 16mm designation up to 90 KN discs and 20 mm designation for 165KN discs, in accordance with the standard dimensions stated in IS : 2486-(Part-II) or equivalent International Standards. The dimensions shall be checked by the appropriate gauge after galvanising only.

6.7.6 **Security Clips and Split Pins**

6.7.6.1. Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking 9f the coupling as per IS: 2486-(Part-III)or equivalent International Standards. The legs of the security clips shall be spread after assembly in the works 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 the locking devices allow separation of fittings.

6.7.6.2. The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall neither be than 50 N (5 kg) nor more than 500 N (50 kg).

Split pins shall be used with bolts & nuts.

6.7.7 **Arcing Horn for EHV Strings**

6.7.7.1. The arcing horn shall be provided on tower side of the hardware fittings. The same shall be either ball ended rod type or tubular type.

6.7.7.2. The spark gap shall be so adjusted to ensure effective operation under actual field conditions.

6.7.8 **Turnbuckle**

6.7.8.1. 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.

6.7.8.2. The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 380 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing submitted with the bid. An adjustment of 135 mm minimum shall be possible with turnbuckle.

6.7.9 **Suspension Assembly**

6.7.9.1. 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 and without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.

6.7.9.2. The suspension assembly/clamp shall be so designed so that it minimises the static and dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs and have required level of Corona/AIV performance.

6.7.10 **Standard Preformed Armour Rod Set**

6.7.10.1. The Preformed Armour Rod Set suitable for 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 clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

6.7.10.2. The preformed armour rods set shall have right hand lay and the inside diameter of the helices shall be less than the outside diameter of the conductor in order to gently but permanently grip the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions, etc.

6.7.10.3. The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

6.7.10.4. The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

6.7.11 **Dead End Assembly**

6.7.11.1. The dead end assembly shall be suitable for Conductor as detailed in the document.

6.7.11.2. The dead end assembly shall be compression type with provision for comprising the jumper terminal at one end. The angle of the jumper terminal to be mounted should be 300 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. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

6.7.11.3. The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

6.7.12 **Fasteners: Bolts, Nuts and 'Washers**

6.7.12.1. All bolts and nuts shall conform to IS: 6639or equivalent International Standards. All bolts and nuts shall be galvanised as per IS-1367 -(Part 13)/IS-2629or equivalent International Standards. 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.

6.7.12.2. Bolts upto 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 arid effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS-12427or equivalent International Standards. Bolts should be provided with washer face in accordance with IS: 1363 Part-1or equivalent International Standards to ensure proper bearing.

6.7.12.3. Nuts should be double chamfered as per the requirement of IS: 1363 Part-IIIor equivalent International Standards. 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

6.7.12.4. Fully threaded bolts 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.

6.7.12.5. 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 no 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.

6.7.12.6. Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS: 2016.

6.7.12.7. The Bidder shall furnish bolt schedules giving thickness of components connected. the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

6.7.12.8. To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

6.7.12.9. Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

6.7.12.10. Fasteners of grade higher than 8.8 are not to be used.

6.7.13 **Materials**

The materials of the various components shall be as specified hereunder. The Bidders hall indicate the material proposed to be used for each and every component of hardware fittings stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

6.7.14 **Workmanship**

6.7.14.1. All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for rated voltage of transmission lines and will give continued good performance.

6.7.14.2. The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and comers to limit corona and radio- interference, best resistance to corrosion and a good finish.

6.7.14.3. All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall he done in accordance with IS: 2629 / IS-1367 (Part 13)or equivalent International Standards and shall satisfy the tests mentioned in IS: 2633-1986or equivalent International Standards. Fasteners shall withstand four dips while spring washers shall withstand three dips of one-minute duration in the standard Preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 610 gm / sq.m shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard price test for galvanizing.

6.7.14.4. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

6.7.14.5. The zinc coating shall be perfectly adherent of uniform thickness, smooth, reasonably bright. Continuous and free from imperfections such as flux, ash, rust, stains, bulky white deposits and blisters. The zinc used for galvanizing shall be grade Zn 99.95 as per IS: 209or equivalent International Standards.

6.7.14.6. Socket ends, before galvanizing, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions, of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486or equivalent International Standards.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

6.7.14.7. In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm

6.7.14.8. All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

6.7.14.9. No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the inductor in any way during erection or during continuous operation which would product high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

6.7.14.10. All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

6.7.14.11. All fasteners shall have suitable corona free locking arrangement to guard against Vibration loosening.

6.7.15 **Bid Drawings**

6.7.15.1. The Bidder shall furnish full description and illustrations of materials offered.

6.7.15.2. Fully dimensioned drawings of the complete insulator string hardware and their component parts showing clearly the following arrangements shall be furnished in five (5) copies along

with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

(i) Suspension or dead end assembly.
(ii) Arcing horn attachment to the string
(iii) Hardware fittings of ball and socket type for inter connecting units.
(iv) Corona control rings/grading ring attachment to conductor and other small accessories.

6.7.15.3. All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

(i) Dimensions and dimensional tolerance.
(ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & 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 terminal details.

6.7.15.4. After placement of award, the Contractor shall submit fully dimensioned drawings including all the components in four (4) copies to the Employer for approval. After getting approval from the Employer and successful completion of all the type tests, the Contractor shall submit thirty (10) more copies of the same drawings to the Employer for further distribution and field use at Employer's end.

6.7.16 **Completeness of works**

Bidder shall assess the complete requirement of line hardware, hardware accessories and assemblies in complete for the erection of the lines as per the recommended erection practices.

The hardware assemblies shall be supplied complete with components, sub-components, nuts, bolts, washer etc. fittings and accessories for conductor & earth wire like Mid Span Joints, Repair Sleeves, and Stockbridge Vibration Dampers.

The Contractor shall also supply all line and tower accessories.

6.7.17 **Standards**

6.7.17.1. The Hardware Fittings, conductor and OPGW accessories shall conform to the following Indian Standards or equivalent International Standards, which shall mean latest revisions, amendments/changes adopted and published unless specifically stated otherwise in the specification.

1.	IS: 209	Specification for Zinc.
2.	IS: 398	Specification for Aluminum Conductors. for Overhead Transmission Purposes,
3.	IS: 1327	Method of Determination of Weight of Zinc Coating on Tin Plate.
4.	IS: 1573	Electroplated Coating of Zinc on Iron and Steel

5.	IS: 2121	Specification for Conductors Accessories for Overhead Power Lines
	(Part-1)	Armour Rods, Binding Wires and Tapes for Conductors
	(Part-2)	Mid-span joints and Repair Sleeves for Conductors
6.	IS : 2486	Specification for Insulator Fittings for Overhead Power Lines With a Nominal Voltage Greater than 1 000 V
	(Part 1)	General Requirements and Tests
7.	IS:2629	Recommended Practice for Hot Dip Galvanizing of Iron and Steel
8.	IS:2633	Method of Testing Uniformity of Coating on Zinc Coated Articles
9.	IS:4826	Galvanized Coating on Round Steel Wires
10.	IS : 6639	Hexagonal Bolts for Steel Structures
11.	IS: 6745	Methods for Determination of Weight of Zinc Coating on Zinc Coated Iron and Steel Articles
12.	IS : 8263	Method for Radio Interference Tests on High Voltage Insulators
13.	IS : 9708	Specification for Stock Bridge vibration Dampers for Overhead Power Lines

6.7.18 **TESTS**

The insulator discs and hardware fittings shall be subjected to the tests before despatch, in accordance with the relevant standards. The successful contractor shall submit the test results in quadruplicate to the Employer.

6.7.19 **MARKING**

Each insulator disc shall be legibly and indelibly marked with the following:

- Name or trade mark of the manufacturer.
- Month and year of manufacture.
- Minimum failing load in Newton.
- Country of manufacture
- Standard certification mark, if any.

The marking of the porcelain shall be printed and shall be applied before firing

SECTION - 7

TECHNICAL SPECIFICATION
CONDUCTORS, OPTICAL GROUND WIRES AND ACCESSORIES FOR CONDUCTORS AND OPTICAL GROUND WIRES

7.1.0 SCOPE

7.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor, G.I. Earth Continuity wires (Ground Wires) and accessories for Power Conductors and Earth Wire.

7.2.0 POWER CONDUCTOR

7.2.1 TYPE OF CONDUCTOR

The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM:B-232 except where otherwise specified herein.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

7.2.2 **STANDARD TECHNICAL PARTICULARS**

All ACSR Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

7.2.3 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.

The steel strands shall be hot dip galvanised and shall have a minimum zinc coating.

7.2.4 **MATERIAL**

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889.

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 : 60888.

The zinc used for galvanizing shall be electrolytic High Grade Zinc of purity. It shall conform to and satisfy all the requirements of IS:209.

7.2.5 **JOINTS IN WIRE**

In the Aluminium wires 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.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

In the 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.

7.2.6 **STRANDING**

The wires used in construction of a ACSR conductor shall, before and after stranding, satisfy all requirements as per IS 398.

The lay ratio of the different layers shall be within the limits as per the said Standard. In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded. In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

7.2.7 **TYPE/ROUTINE/ACCEPTANCE TESTS**

7.2.8 **Type Test:**

The following tests shall be conducted on a sample/samples of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

a) DC resistance test on stranded conductor
b) UTS test on stranded conductor
c) Corona extinction voltage test (dry)
d) Radio interference voltage test (dry)

7.2.9 **Acceptance Test:**

a) Visual and dimensional check on drum
b) Visual check for joints, scratches etc. and length measurement of conductor by rewinding
c) Measurement of diameters of individual Steel and Aluminium strands

Galvanizing test on steel strands

Check for lay Ratios of various layers

Torsion and Elongation tests on steel strands

Breaking load test on steel and Aluminium strands

Wrap test on Steel & Aluminium strands

DC resistance test on Aluminium strands

Procedure qualification test on welded joint of Aluminium strands

Drum strength test (steel drum)

Barrel Batten strength test (wooden drum)

The above acceptance tests shall be repeated on one conductor sample taken from site in presence of AEGCL's representative for each 500km progressive supply. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by AEGCL's site representative and the tests shall be witnessed by AEGCL's representative.

7.2.10 **Routine Tests:**

Check to ensure that the joints are as per Specification

Check that there are no cuts, fins etc. on the strands

Check that drums are as per Specification

All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

7.2.11 **Tests During manufacture:**

Chemical Analysis of Zinc used for galvanising

Chemical Analysis of Aluminium used for making Aluminium Strands

Chemical Analysis of Steel used for making Steel Strands.

7.2.12 **REJECTION AND RETESTS**

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

7.2.13 PACKING

7.2.14 All conductor reels shall conform to latest edition of IS : 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings. All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings. All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging. The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner. The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

7.2.15 TECHINCAL DATA SHEET FOR CONDUCTOR

Sl. No.	DESCRIPTION	ACSR 'PANTHER'
1	Code name	PANTHER
2	Number of strands & size	Al: 30/ 3.00 mm St: 7/ 3.00 mm

3	Overall diameter	21.00 mm
4	Breaking load	130.32 kN
5	Weight of conductor	974 kg / km
6	Co-efficient of linear expansion	$19.35x10^{-6}$ /^{0}C
7	Number of strand	
	Steel centre	1
	1st Steel Layer	6
	1st Aluminium Layer	12
	2nd Aluminium Layer	18
	3rd Aluminium Layer	-
8	Sectional area of Aluminium	212.10 mm^2
9	Total sectional area	261.50 mm^2
10	Calculated d.c. resistance at 20^0 C	0.1400 ohm/km
11	Ultimate tensile strength	89.67

7.4.0: TECHNICAL SPECIFICATION FOR OPTICAL GROUND WIRE (OPGW)

7.4. 0 FIBRE OPTIC CABLES PARTICULAR SPECIFICATIONS (OPGW AND APPROACH CABLES)

7.4.1 OVERVIEW AND GENERAL REQUIREMENTS

OPGW and approach cables are required to provide:

- Ground/earth shielding of the 132KV/220KV/400 KV new lines under this project and
- Use the OPGW/Approach fibre component to the new 132KV/220KV/400KV grid substations of AEGCL to the existing Fibre Optic Network that can support grid communications with SLDC. The proposed augmentation will enable integration of SAS of the grid substations to SLDC. The new Fibre Optic Network will also enable transmission of Tele-protection and Tele-control Signalling; other Data transfer, Voice/Telephony and an Energy Management (EMS) System as fibre media-based functions of its grid communications network and enhanced operation and maintenance of Assam's transmission system and also non power utility communications.

7.4.2 STANDARDS

The following standards and codes shall be generally applicable to the equipment and Works supplied under this Contract:

(1) American Society for Testing and Materials ASTM-B415, ASTM-D1248, ASTM D3349.

(2) ITU-T/CCITT Recommendations G.650, G.652, G.653, G.655.

(3) Institute of Electrical and Electronics Engineers IEEE-812, 1138-1994, IEEE-524, IEEE-828 & 830 and latest amendment of IEEE 1138.

(4) Electronic Industries Association, EIA-455-3, 455-25A, 455-31B, 455-32, , 455-41, 455-91, 455-78, 455- 59, 455-80, 455-81, 455-169, 455-81, EIA RS 598

(5) International Electro technical Commission standards, IEC -1396 and IEC - 1089.

(6) International Electro technical Commission standards, IEC 61395, IEC 793-1, 793-2, 794-1, 794-2, IEC-529, IEC 60794-1-2, IEC 60794-4-10.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Bidder shall attempt to comply with such, provided that no additional expenses are charged to the Owner without Owner's written consent.

In addition, and particular recognition of this Contract's purpose to deliver a Fibre based power utility grid operation communication network the following reference documents are to be made available to the Employer its Project Manager and there content reflected as appropriate in the Contractor's Facilities detailed engineering design and implementation programme. These additional reference documents are:

i. CIGRE Guide for Planning of Power Utility Digital Communications Networks

ii. CIGRE Optical Fibre Planning Guide for Power Utilities

iii. CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities

iv CIGRE guide to fittings for Optical Cables on Transmission Lines.

7.4.3 BASIC TECHNICAL DATA

7.4.3.1 Site and Service Conditions

The OPGW and the Communication Equipment covered under this Contract are to run entirely within the State of Assam, India and shall be suitable for the topical climatic conditions prevailing in the Project areas as mentioned in chapter 2 of this bidding document.

7.4.3.2 Fibre optic cabling

The OPGW shall have 96 nos. optical fibres. The OPGW cable, associated hardware and fittings shall meet the requirements of G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. 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.

7.4.3.3 Required optical fibre characteristics

The optical fibre to be provided should have following characteristics.

7.4.3.4 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristic.

7.4.3.5 Physical Characteristic

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 1-1(a).

7.4.3.6 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 1-1 (a) 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 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-1

DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 µm (± 0.6 µm)
Cladding Diameter:	125.0 µm ± 1 µm
Mode field concentricity error	≤ 0.6µm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength lcc	≤ 1260 nm
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤0.21 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	≤0.2 ps/km$^{\lambda 1/2}$
Temperature Dependence:	Induced attenuation £ 0.05 dB (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns;

	Attenuation Rise ≤ 0.05 dB @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

7.4.3.7 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable 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 requirements of all the transmission lines.

7.4.3.8 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices/Section Project/BoQ as transmission line route length. However, 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. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

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.

7.4.3.9 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 is 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.

7.4.3.10 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.

7.4.3.11 Optical Fibre Strain & Sag-Tension chart

The OPGW 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
- 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 max. 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 in line with the design parameter of transmission line. The typical details are indicated in the Appendix A. 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.

7.4.3.12 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

7.4.3.13 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibiting 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 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-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 encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

7.4.3.14 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

7.4.3.15 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.

7.4.3.16 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. 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 multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single

buffer tube or directly in central fibre optic unit is not acceptable. 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.

7.4.3.17 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.

Transmission Line Voltage and Wind Zone	**OPGW Cable Parameters**						
	UTS (kg)	**Area (sqmm)**	**Wt (Kg/m)**	**Dia (mm)**	**Modulus of Elasticity (Kg/sqmm)**	**Coeff of Linear Expansion (per deg c)**	**Central Fibre Optic Unit Design**
400kV M/C WZ 1-4 400kV D/C WZ 1-5	9350± 150	56.5±2.5	0.45±0.01	12±0.2	14290±110	0.0000138± 0.0000003	Al tube
220kV D/C WZ 1-4 132kV D/C WZ 1-5	7376±50	51±2	0.355±0.01	11.4±0.2	12344±100	0.0000149± 0.0000003	Al Tube
River Crossing Section	20059± 100	118±5	0.884±0.01	14.7±0.2	16355±100	0.0000127± 0.0000003	Stainless Steel Tube

Table: OPGW Parameters to be considered for different line voltage and wind zone

7.4.3.18 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 1.2(a) 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.

7.4.3.19 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.

7.4.3.20 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earth wire 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 1.2(a)
OPGW Electrical and Mechanical Requirements

(1)	**Everyday Tension**	≤20% of UTS of OPGW
(2)	**D.C. Resistance at 20ºC:**	< 1.0 ohm/Km
(3)	**Short Circuit Current**	≥ 6.32 kA for 1.0 second

7.4.3.21Operating conditions
Since OPGW shall be located at the top of the 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.
7.4.3.22 Installation
OPGW installed under live line condition, i.e. with all circuits charged to the rated line voltage as specified in this section shall be generally in accordance with the IEEE Guide to the Installation of Overhead Transmission Line Conductors (IEEE STD. 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling.
A tower structural analysis shall be carried out by the Contractor wherever required, based on the relevant data to be provided by Employer, to ensure that with the replacement of existing earth wire with the OPGW cable, the tower members remain within the statutory safety limits as per Indian Electricity rules and if required the Contractor shall carry out the tower strengthening as necessary at no additional cost to Employer. 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 at no additional cost to Employer.
7.4.3.23Installation Hardware
The scope of supply includes 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 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 to 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 particular 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. 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 1m/s to 7 m/s, 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 technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

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 and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or 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 projections, 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 designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS:4826 for heavily coated wires.

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, 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 2.5 kN and 5 kN. 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 characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows

Sl No	Description	Technical Particulars
1	Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span:	 400 meters 1100 meters 100 meters
2	Configuration:	As per Specifications

3	Tensile load in each:	As per sag tension calculations
4	Armour rods used:	Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain:	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor.
Placement charts should be duly supported with relevant technical documents and sample calculations.
The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.
(2) Placement distances clearly identifying the extremities between which the distances are to be measured.
(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)
(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

7.4.3.24 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 with 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 12 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 anticlimb 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.

7.4.3.25 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.
(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.

7.4.3.26 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices/BoQ. However, the Contractor shall supply & install the optical fibre 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.

7.4.3.27 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.

7.4.3.28 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. 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 pollution. The jacket shall conform to ASTM D1248 for density.

7.4.3.29 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

7.4.4.0 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres 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 pass-through splicing and fibre 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.

7.4.5.0 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively, connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

7.4.5.1 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 : Connectorized 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.

7.4.6.0 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipment are enumerated in Table 1.3 below and Chapter " Spares and Tools"

Table 1.3

Sl No	Test Equipment	
A.	**Test Equipment for OPGW cable**	
1	OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm	
2	Optical Attenuators (variable 1310/1550nm).	
3	Optical Power meter (1310/1550nm)	
4	Laser Light Source (1310/1550nm)	
5	Optical Fibre Fusion Splicer incl. Fibre cleaver etc	
6	OFC Tool kit consisting of Fibre stripping tool and tools for cutting and stripping of sheathing, jacket armouring of OFAC/ADSS/OPGW cables including two nos of high resolution hand held Binoculars	
7	Optical test accessory kit including all Necessary connectors, adaptors, cables, terminations and other items required for testing	

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer.

7.4.7.0 Inspection & 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 provide all manpower and materials for tests, including testing facilities, logistics, 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, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes 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.

7.4.8.0 Testing Requirements

Following are the requirements of testing :

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

7.4.9.0 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All cable & 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 proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.
(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

7.4.9.1 Type Test Sample

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

7.4.9.2 List of Type Tests

The type testing shall be conducted on the following items

(a) Optical fibres
(b) OPGW Cable
(c) OPGW Cable fittings
(d) Vibration Damper
(e) Splice Enclosure (Joint Box)
(f) Approach Cable

7.4.9.3 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

SL. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-01 of TS	IEC 60793-1-40Or 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 OrEIA/TIA 455-176
9	Point Discontinuities of		IEC 60793-1-40 Or

	attenuation		EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 OrEIA/TIA 455-176
11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B

7.4.9.4 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 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.

S. No.	Test Name	Test Description	Test Procedure	
1	Water Ingress Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	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 1138-2009 Or IEC60794 4-10 / IEC 60794-1-2, Method E19	IEEE 1138-2009	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

S. No.	Test Name	Test Description	Test Procedure	
5	Galloping test	EEE 1138-2009	IEEE 1138-2009	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 1138-2009 OR IEC 60794-1-2 (2003) Method E1B	IEEE 1138-2009	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 1138-2009	IEEE 1138-2009 (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.
9	Impact Test	IEEE 1138-2009	IEEE 1138-2009, (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 permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.

S. No.	Test Name	Test Description	Test Procedure	
10	Creep Test	IEEE 1138-2009	IEEE 1138-2009	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 1138-1994	IEEE 1138-1994	
12	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009	
13	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009	
14	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-2009	
15	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 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	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.		

7.4.9.5 Type Test on OPGW Cable Fittings

The type tests to be 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 16o. 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 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 an 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 increase 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.

7.4.9.6 Type Test on Vibration Damper

(a) 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 ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. 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.

(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 fibre optic cable without dampers.

Acceptance criteria for vibration damper:

(i) The above dynamic characteristics test on five dampers 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 following limits: V.D. for OPGW - 0.060 f to 0.357 f kgf/mm* Where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25o to 130o 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.

(b) 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 fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable 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.

(vi) 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.

(c) Fatigue Tests

(i) Test Set Up

The 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 25% of RTS of fibre optic cable 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) 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 ±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 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:

(1) There shall not be any resonant frequency shift before and after the test by more than ± 20%

(2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20% Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper.

Sl 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	Attachments 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

7.4.9. 7 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated 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 ±0.05dB. 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 ±2□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 ±0.05dB, 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 ±0.05dB.

(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 ±0.05dB. 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 ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. 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 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

7.4.9.8 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre 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.

Sl No	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling	(EIA 455-81A)
	compound	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

7.4.9.10 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 ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

7.4.9.11 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

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 Employer 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 tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general, the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc. For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

7.4.9.12 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 minimum 10% of the batch size (minimum 1) for all 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 cable 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, FODPs, 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.

7.4.9.13 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.

7.4.9.14 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. 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 2-4
Factory Acceptance Tests for Optical Fibres: Optical Tests

Sl No	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation Coefficient	T S,Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Point Discontinuities of attenuation	TS ,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 fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

7.4.9.15 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table 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 2-5
Factory Acceptance Tests on OPGW

Applicable standard: IEEE 1138 / IEC 60794

Sl 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

7.4.9.16 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

Table 2-6

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 messenger cable
	Factory Acceptance Test
15	Attachments of clamps to 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

7.4.9.17 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7

Factory Acceptance Tests On Approach Cable

Sl 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

7.4.9.18 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2 8

Table 2-8

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/FODP and dimensional checks against the approved drawings.

7.4.9.19 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

7.4.9.20 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & 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. At a minimum Site Acceptance Testing requirement for FO cable etc. 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 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.

7.4.9.21 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.

7.4.9.22 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 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 Table 2- 9(a) through 2-9(c) below:

Table 2-9(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 2-9(b)

Fibre Optic Cable Splicing Testing

Item:	Description:
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 2-9(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.

7.4.10 Installation of OPGW Cabling

7.4.10.1 OPGW cable installation requirements

The following shall be under the scope of OPGW Cabling:

- Supply of OPGW Cable & Hardware Fittings needed to tie the OPGW cable to the towers/gantries.
- Supervision of stringing of OPGW Cable at sites as per instruction by Employer. The supervision shall include the inspection as per stringing procedure, proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations
- The Splicing work of OPGW Cable and after that testing of link.

7.4.10.3 Installation Hardware

All required hardware's shall be installed along with OPGW Cable.

7.4.10.4 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.

7.4.10.5 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

7.4.10.6 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

7.4.10.7 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.

7.4.16.0 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 anticorrosion 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

CHAPTER 7.5: SPECIFICATIONS FOR COMMUNICATION EQUIPMENT FOR ESTABLISHMENT OF FIBRE OPTIC COMMUNICATION SYSTEM

7.5.0 Introduction, General Information and General Requirement

This Chapter describes the technical specifications for Communication Equipment for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

29.1 Scope and General Requirements

The broad scope of the procurement of this part include the survey, planning, co-ordination with other suppliers' equipment, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for

(i) SDH Equipment along with suitable optical line interfaces & tributary cards.
(ii) Integration with existing NMS at SLDC.
(iii) All cabling, wiring, Digital Distribution Frame patch facilities and interconnections to the supplied equipment at the defined interfaces.
(iv) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH
(v) Integration of supplied system with the User equipment such as RTUs, SCADA system SAS etc.
(vi) Maintenance of the supplied system
(vii) Integration/Interfacing with PLCC/DPC

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

The network shall comprise multi input and multi output fibre optic equipment complete for speech communication in dialling mode and or through express telephone, data communication, fibre optic based power system protection, suitable for multi point to multi point fibre optic network. The terminal optical communication equipment shall be installed in the Sub Stations to be constructed under this Package (only for 400kV Voltage Level.

The responsibility of connecting the optical terminal equipments with the FODP of the respective substation shall rest with this contract. Also, the connection of OLTE with FODP is within the scope of this contract..

7.2 General Requirements

29.2.1 It should be noted that preliminary design information and bill of quantity (BOQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BOQ as required for ultimate design & system performance.

29.2.2 The Tenderer's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

29.2.3 An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional communication equipment system is implemented that meets or exceeds the capacity, and performance requirements specified. Such materials and services shall be considered to be within the scope of the contract. To the extent possible, the Tenderers shall identify and include all such additional items and services in their proposal.

29.2.4 All telecom equipment provided shall be designed to interface with existing telecom equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

29.2.5 The communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

29.2.6 The Tenderer is supposed to make necessary survey for integration of the SDH Equipment with the existing NMS at SLDC, Kahilipara. For this if any traffic routing to SLDC is required through other Utilities; AEGCL will arrange the same. However, during interfacing with the existing telecom equipment if any hardware/software is required (at SLDC or Remote end), the Bidder has to offer the same with no cost implication to AEGCL.

29.2.7 The Tenderers are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful tenderer (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities. After the site survey, the Contractor shall submit to the Employer a survey report

on each link and site. This report shall include at least the following items:

(a) Proposed layout of Equipment in the existing rooms and buildings.
(b) Proposed routing of power, earthing, signal cables and patch cords etc.
(c) Confirmation of adequacy of Space and AC/DC Power supply requirements
(d) Proposals for new rooms/buildings if required
(e) Identification of facility modifications if required
(f) Identify all additional items required for integration for each site/location.

29.2.8 Synchronization of the Communication Network

The Contractor shall be responsible for synchronization of new communication equipment with existing network utilizing the existing GPS clock. The Contractor shall make an assessment of additional clock requirement for synchronization of the communication equipment.

29.3 General Responsibilities and Obligations

This section describes the general responsibilities and obligations of the Contractor and the Employer.

29.3.1 Responsibilities for the Implementation Plan

The Tenderer's technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in this specification. The implementation plan shall be modelled such that it provides fibre optic cabling system support for the activation of this Project. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the Employer. The Employer and Contractor shall finalise the detailed Implementation plan following award of the contract.

29.3.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cables and wiring associated with the equipment provided, both inside and outside buildings in accordance with technical specifications. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for wiring to it, with adequate circuit protective breakers. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment, and for earthing all cabinets and shields.

Contractor's obligations include, but are not limited to, the following:

(1) Site visits, and surveys, necessary to identify and provide all equipment needed to implementation the network.
(2) Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.
(3) Overall integration of communication equipments/subsystem procured in present with existing User equipments such as SDH, RTUs, SCADA, SAS system with SLDC, Kahilipara etc.
(4) All cabling, wiring including supply, laying and termination etc of the cables, and distribution frame at wideband nodes required for full interconnectivity and proper operation of the telecommunications network including equipment supplied under this package and the connectivity and interfacing of user equipment.
(5) Installation and integration of network management software, hardware and firmware.
(6) Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.
(7) Engineering and technical assistance during the contract and warranty period.
(8) Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, trenches necessary for installation of proposed equipment and provide the details of such work to the Employer.
(9) Factory and site testing of all hardware, software, and firmware provided.
(10) Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.
(11) Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.
(12) Training of the Employer personnel.
(13) Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment through out the warranty period.
(14) Availability of service, spare and expansion parts for the supplied items for the designed life of the equipment or seven (7) years after the declaration of withdrawal of equipment from production, whichever is earlier. However, the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

Detailed descriptions of the Contractor's obligations, in relation to individual items and services offered, are delineated in other sections of this specification.

29.3.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

(1) Overall project management of the project
(2) Review and approval of the Contractor's designs, drawings, and recommendations.
(3) Communication network configuration data, including:
    (a) Channel assignments for voice and data
    (b) Interconnection drawings for existing equipment
(4) Review and approval of test procedures.
(5) Participation in and approval of "Type", factory and site acceptance tests where testing is required.
(6) Review and approval of training plans.
(7) Providing support and access to facilities at the sites.
(8) Implement the major civil works such as expansions or construction of rooms, trenches etc. as required for the equipment to be provided by the Contractor.
(9) Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.
(10) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.
(11) Approval of the key personnel for the project

29.4.0 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed. The parameters not specifically mentioned in this specification shall conform to the standard mentioned in this specification.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the
contract, the Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

29.5.0 Network Configuration and Equipment Characteristics

29.5.1 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fibre Optic Transmission System (FOTS)
(2) Craft Terminal based Network Management System (NMS)
(3) DDF and Cabling

The requirements described herein are applicable to and in support of network requirements.

29.5.2 The security related requirements of the equipment shall be as per DOT (Department of Telecommunication)/ MEITY (Ministry of Electronics and Information Technology) guidelines and all similar security requirements as amended by DoT on time to time basis shall be followed/complied by the vendor at no additional cost to employer till the implementation of the project..

29.5.3 The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security /threat check any time during the supplies of equipment.

29.5.4 The contractor shall ensure that the supplied equipment have been tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be done from authorized and certified agency/lab in India.

29.5.5 The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. Supplied and implemented in the project shall be given for use by the Employer.

29.5.6 The contractor shall get the Employer's equipment audited from security point of view once a year from a network audit and certification agency as identified by DoT. The audit of the equipment shall be carried once in a financial year till the maintenance service contract in the tender.

29.5.7 In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of DoT and any other Government department.

29.6.0 General Network Characteristics

29.6.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH). The network shall consist of overhead fibre optic links with a minimum bit rate of Synchronous Transport Module-STM-16 (STM-16). The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices. The fibre optic network shall also be able to integrate with existing STM-1 network.

29.6.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTUs/SAS. The communications support requirement for SCADA/EMS/RTUs/SAS system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

(a) High speed E1 channel support

(b) 64kbps & nx64kbps data channel support

(c) Low speed (300-1200 bps) data channel support

(d) Voice (2 wire, 4 wire) channel support

(e) Network Management channels either through (Data Communication Channel(DCC) or through data channel as may be suitable as per site requirement.

(f) The connectivity envisaged for RTUs and SAS with Control Centre (SLDC, Kahilipara) over TCP-IP is Wide Area Network on TCP-IP using IEC 60870-5-104 and IEC 60870-5-101 protocol.

(g) Tele-protection interface for simultaneous transmission and reception of trip (tele-protection) signal from/to one station to/from another two three or more stations. Tele-protections unit should be capable of communicating with remote end tele-protections directly or through fibre with 64kbps or E1 as back up path through fibre optic equipment.

29.6.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

29.6.3.1 System Synchronization

The Contractor shall synchronize the existing equipment and all the new equipment under the contract

using existing Master clock. The Contractor shall provide the additional clocks as required under the set of clock indicated in BOQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interface(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

29.6.3.2 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control with graphical user interface. Such testing shall not affect the functional operation of the system.

29.6.3.3 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies and NMS shall be sized for maximum equipped system capacity.

29.6.3.4 Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The average per link subscriber to subscriber availability shall be at least 99.97%. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers between SAS/RTU to reporting Control Centres and between control centres.

The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the meantime- to-repair (MTTR) of the components and subsystems comprising the FOTS. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations.

In order to ensure that the equipment and configuration proposed by the Tenderers shall capable of demonstrating the specified availability figures it is required that the Tenderer shall include in their proposal a calculated availability analysis for the proposed equipment/sub system. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided by the Contractor during detailed engineering. The analysis shall be based on an availability block diagram and shall include the mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR) of all the components on the link. The Tenderer shall indicate in the analysis the MTBF and MTTR and the resulting availability of each poini-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

The Tenderer shall carry out the survey at respective Sub-Stations and other linking Sub-Stations to assess the requirements. The required wiring and cabling for the integration with new & existing OPGW systems, new & existing Fibre Optic System, new and existing EPAXs, space requirements, power supply

requirements. Placing of proposed FOTS equipment with FODP shall also be assessed by the Tenderer during the Site Survey.

29.6.3.5 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement
shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

29.6.3.6 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BOQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion. Data communications channelization required to support the NMS subsystems specified in Technical Specifications (TS) are not identified in the appendices. Therefore, the Contractor is required to size and equip the system to include all channelization and channel cards required to support the NMS function.

29.6.3.7 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

Table 2-1
Equipment Redundancy Requirements Summary

Fiber Optic transmission Equipment : **SDH equipment**	
Power Supply & Converters ----------	1:1 APS
Common Control* Cards ----------	1:1 APS
Common control cards which are essentially required for operation of the equipment.	1:1 APS
DACS(Cross Connect)----------	1:1 APS
Power Supply----------	1:1 redundant
Multiplexer power supply----------	1:1 APS

The offered equipment shall support at least SNCP **as per standard ITU-T G.841**. In case the equipment offered by the Tenderer does not support the above mentioned minimum protection methods, the tenderer shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The tenderers shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

29.6.3.8 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

29.6.3.9 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

29.6.3.10 General Site Considerations

In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored by centralized NMS.

29.6.3.11 Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:

Table-2-2
Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 μm (±0.6 μm)
Cladding Diameter:	125.0 μm + 1μm
Mode field Concentricity Error:	≤ 0.6μm
Core-Clad concentricity error:	≤ 1.0μm
Cladding non-circularity	≤1%
Cable Cut off Wavelength:	≤1260 nm
1550 loss performance	As per G.652D
Proof Test Level	□□0.69 Gpa
Attenuation coefficient	@1310nm ≤ 0.35 dB/Km @1550nm ≤0.21 dB/Km
Attenuation variation with wavelength **1285 nm - 1330 nm** **1525 nm – 1575 nm**	 Attenuation coefficient @1310 ± 0.05 dB Attenuation coefficient @1550 ± 0.05 dB
Point discontinuities	≤ 0.1dB
Chromatic Dispersion; Max.: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18.0 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/(nm2xkm) maximum
Polarization mode dispersion coefficient	< 0.2 ps/km^1/2
Temperature Dependence:	Induced attenuation < 0.05 dB (-60 deg C - +85 deg C)
Bend performance:	@1310nm (75+2 mm dia Mandrel), 100 turns; Attenuation rise □□0.05 dB @1550nm (30+1 mm dia Mandrel), 100 turns; Attenuation rise □□0.10 dB @1550nm (32+0.5 mm dia Mandrel), 1 turn; Attenuation rise □□0.50 dB

29.7.0 **Fibre Optic Link Lengths**

The fiber optic route lengths are as specified in appendices/Section Project/BoQ. The lengths specified in appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an additional cable length of 5% of given route length **+** 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project.

29.7.1 Fibre Optic Transmission System

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-16 and equipped with 2 nos. Of minimum 63 port E1 interface (G.703) card, two no. of minimum 8 port Ethernet interface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE802.1P/Q), spanning tree (IEEE 802.1D) quality of service. Protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032..

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

29.8.0 SDH Equipment

29.8.1 Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The Price schedule shall be referred for BOQ. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If tenderer is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, control card shall not be equipped with more than one optical interface/SFP and optical base card shall not be equipped with more than two optical interface/SFPs.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

29.8.2 SDH ADM

The aggregate interfaces shall be STM-16 towards at least 5 (five) protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 2 nos., min. 63 E1 port electrical tributary cards & one no., min. 8 port Ethernet interface card as tributaries. The equipment shall provide access to full STM16 payload. The equipment shall provide non blocking cross connect capability of 64 STM-1 (bi-directional) at high order VC-4 level and as well as low order VC-12 level. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-16 equipment.

29.8.3 Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

29.8.4 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: 8 voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and 4 data channel with opto coupler interface for V.24/V.28 interface. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

29.8.5 Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the NMS.

29.8.6 Synchronisation

The equipment shall provide synchronisation as per Table 2-2. One 2MHz synchronisation output from each equipment shall be provided.

29.8.7 Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 2-3
Electrical and Optical I/O Characteristics and General Parameters

Optical Wavelength NOTE (1)	1310/1550nm
Optical Source NOTE (2)	Laser
Optical Source Lifespan	Better than 5 X10^5 hours
Optical Fibre Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 Ω
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.813
Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

NOTE (2) **Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

NOTE (3) In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

29.9.0 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

29.9.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

(1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

(2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

(3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

(4) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed “End of Life (EOL)” parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

(5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

(6) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10}.
The tenderers shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering.

For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

29.9.2 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.
FOTS equipments shall be provided with in-built loopback capabilities : Each FOTS transceiver pair shall be able to provide local(manual) and remote on demand loopbacks of the composite baseband and each E-1 port.

29.10.0 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP(to be provided under separate contract) and the SDH equipment. The Contractor shall provide FC PC coupled patch cords of suitable length as per requirement. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

29.11.0 DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities to the wideband telecommunications system. Equipment and material components for DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

29.12.0 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

(i) "Normally thru" circuit routing

(ii) Circuit rerouting via patch cord assemblies
(iii)Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

29.12.1 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

29.13.0 Telecommunication Management Network / Network Management System

The Contractor shall provide Craft Terminal based Telecommunications Management Network System (NMS) for operational support to the FOTS subsystems (if required). This NMS shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network with the help of a portable personal computer to be known as craft terminal. The Contractor shall submit for Employer's approval the NMS architecture describing in detail the following subsystems/features:

(a) Database used in NMS
(b) Peripherals and hardware
(c) Software and operating system
(d) Craft Terminals

29.14.0 Management Functions

The NMS shall support following Management functions:

29.14.1 Configuration Management

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.
b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.
c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.
d. Provide verification testing to support new equipment installation.

29.15.0 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.

b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.

c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be

configurable as critical alarms, major alarms and minor alarms with different colours.

d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.
e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.
f. Track network equipment failure history.

29.16.0 Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request.

b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources. Specifically provide displays to permit the operator to:

1. Select/deselect network equipments, events, and threshold parameters to monitor
2. Set monitoring start time and duration or end time
3. Set monitoring sampling frequency
4. Set/change threshold values on selected performance parameters
5. Generate alarm events when thresholds are exceeded.
6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.
8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

29.17.1. Security Management

The NMS shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the NMS system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control. Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

29.17.2. Communication Channel Requirement and Integration

Communication requirements for NMS system have not been considered in Appendices and the Contractor shall provide these as a part of NMS system. The Contractor shall provide all required interface cards / devices etc. The NMS data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible.

29.18 Craft Terminal

Each equipment on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

a. Change the configuration of the station & the connected NEs.
b. Perform tests
c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices

29.19 Hardware Requirements

29.19.1 Craft Terminal

The craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied. The Craft Terminal shall be a laptop. The craft terminal shall have the following minimum configuration:

Parameter	Specification
Compliance	MIL-STD 461F, MIL-STD 810 G
Display	14.0" FHD (1920 x1080)
	1000 nits DynaVue® sunlight readable display with capacitive multi-touch screen
	User selectable touch mode for Finger/Water, Glove, or Stylus programmable function
Operating System	Windows® 10 Pro 64-bit
Processors	Intel® Core™ i7-1185G7 vPro™ (11th Gen) 3.0GHz processor with Turbo Boost Technology up to 4.8GHz, 12MB cache
Memory	2 slots 8GB (3200MHz DDR4)
Storage	Main: 1TB NVME PCIE SSD
Graphics	Intel® Iris® Xe Graphics
Camera	Integrated 2.0 MP web-cam with shutter design
	Optional IR camera for Windows Hello1
Audio	Integrated microphone
	Intel® High Definition Audio Compliant
	Integrated speaker x 2
	Keyboard volume and mute controls
Media Bay (One Option Only)	Optional DVD super Multi Optional 2nd battery Optional SATA SSD
Expansion Box	Optional PCI-Express 3.0 (2 slots)1,6
	Optional discrete VGA1,6
	Optional storage extension with RAID 0/1/5/101,6
	Optional military-grade connectors1
I/O Ports	Thunderbolt 4 (type C) x 1
	USB 3.2 Gen2 (type C) x 1 (support DP)
	USB 3.2 Gen2 (type A) x 1
	USB 3.2 Gen1 (type A) x 1
	USB 2.0 (type A) x 1
	Audio in/out (combo jack) x 1
	microSD card (microSDXC) x 1
	10/100/1000 Ethernet (RJ45) x 2
	VGA port (D-sub,15-pin) x 1

	HDMI port (type A) x 1
	Serial port (RS232 : D-sub,9-pin) x 25
	Docking connector (41-pin Pogo) x 1
	SIM card x 1
	Smart card reader x 1
	DC-In jack x 1
	ExpressCard 54 x 1 (default) or PCMCIA Type II x 1
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Keyboard & Pointing Device	2 user-definable keys (P1/P2)
	RF signal slide-switch
	Standard membrane keyboard with LED backlight
Communications	Integrated 10/100/1000 Ethernet
	Intel® Wi-Fi 6 AX201 (802.11 ax)
	Bluetooth® V5.2
	Optional dedicated GPS module (UBLOX-NEO-M8N)
	Optional 4G LTE multi-carrier mobile broadband
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Security	Intel® vPro™ Technology (per CPU options)
	TPM 2.0
	NIST BIOS compliant
	Easy removable SSD
	Smart card reader
	Stealth mode
	Night vision mode
	Kensington lock
	Optional Windows Hello1
	Optional fingerprint scanner
	Optional HF/LF RFID reader1
Power	AC adapter : 100-240V, 50Hz-60Hz, 90W
	Optional AC adapter (100-240V, 50Hz-60Hz, 120W), with NVIDIA® VGA
	Main battery Li-Ion, 10.8V, 7800mAh, 16 hours2
	Optional 2nd battery Li-Ion 10.8V, 4700mAh, 9 hours2
	Optional bridge battery : 5 minutes swap time3
Dimension & Weight	356 mm (L) x 280 mm (W) x 50 mm (H)4
	3.6 kg
Warranty	3-year limited warranty standard

29.19.2 Power Supplies

The NMS system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

29.20 General Software/Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

29.20.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

29.20.2 Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The contractor shall make no modifications to the applications program except as provided as USER development tools.

29.20.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

29.20.4 Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades of the software or components of the software, shall not be necessary to accommodate full system expansion.

Software provided shall be compliant with national and international industry standards.

20.5 Database(s)

The contractor shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of NMS system.
NMS operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

29.20.6 Help

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

29.21 Environment, EMI, Power Supply, Cabling and Earthing

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

29.21.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

29.21.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

Table 4-1
Environmental Operating Limits

Temperature Range: **Specification** **Operation without damage** **Shipping/storage**	(Un Controlled Environment) 0 to 45°C -10 to 55°C -40 to 60°C
Relative Humidity, non-condensing	Upto 90%
Elevation: **Operating** **Non-operating**	 to 3,000 m to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

29.21.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

29.21.3 Vibration and Shock Resistance

As per testing requirements indicated in this specification.

29.21.4 Tropicalization

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

29.21.5 Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

29.22.0 Primary Source AC/DC Power Requirements

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

29.22.1 Primary Source AC Power

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 240 VAC ± 10%, 50Hz with a frequency variance between 46 and 55 Hz. Harmonic distortion will not exceed five (5) percent. All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 240 VAC supply. The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 240 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

29.22.2 -48V DC Power

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 240 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. **The 48V SMPS battery charger and 48V battery bank for all the 220KV and 132KV substations that fall under this network shall be supplied by the contractor.** The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

29.22.3 TECHNICAL SPECIFICATION 48V BATTERY BANK FOR FOTE (If Required)

29.22.3.1 **TYPE AND RATING**

i) Stationary type, sealed, valve regulated lead acid battery tank suitable for operation on 48 Volts D.C. system to meet loads like emergency lightning, control and signaling circuits, relays, breaker operations, indicating circuits, etc. shall be required. The stationary battery shall comply with the provisions of IEC 896, Part 2 / ANSI T1.330.

ii) The Ampere-hour capacity of the battery bank at 27°C at 10 hours discharge rate shall be 100/200 AH.

iii) The nominal voltage of the battery bank shall be 48 Volts D.C.

iv) The number of cells in a complete battery bank set shall be 24 plus 2 spares.

29.22.3.2 **PLATES**

Positive plates shall be made of flat pasted type using lead-cadmium antimony alloy for durability, high corrosion resistant, maintenance free, long life both in cyclic as well as in ,float applications. Negative plates shall be heavy duty, durable flat plate using lead calcium alloy pasted box grid. Negative plates shall be designed to match the life of positive plates and combination of negative and positive plates shall ensure long life, durability and trouble free operation of battery. PLC operated equipment should be deployed for preparation of paste to ensure consistency in paste quality. Conventional / manual type of paste preparation is not allowed.

29.22.3.3 **CONTAINER AND LID**

The containers and lids shall be made of a special grade polypropylene copolymer plastic material. They shall be sufficiently robust and not liable lo deformation under internal operating pressures and within the temperature range naturally encountered, leak proof, non-absorbent and resistant to the acid with low water vapour permeability.

29.22.3.4 **VENT PLUGS**

Each cell shall be equipped with one-way safety valve with opening pressure of 5±1 psi and closing pressure 4±1 psi. The vent plug shall be made with suitable grade of fire retardant plastic material. Each valve opening shall be covered with flame barrier capable in preventing the ingress of flame into the cell interior when the valve opens and hydrogen / oxygen gas mixture is released.

29.22.3.5 **SEPARATORS**

Separator shall be made of spun glass, micro porous matrix and shall be resistant to Sulphuric Acid. It shall be capable of keeping the entire electrolyte and shall be electrically insulated. Sufficient separator overlap and PVC shield protection to top and bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates.

29.22.3.6 **CONNECTORS**

The connectors shall be lead coated copper of suitable size to join the cells. The connectors shall be suitably designed and coated to withstand corrosion due to sulphuric acid. The coating should be adequate and tenacious. All the copper inter cell connectors shall be provided with heal shrinkable sleeves except at the connecting points.

29.22.3.7 **ELECTROLYTE**

The electrolyte shall be prepared from the battery grade Sulphuric Acid confirming to ISS: 266. The batteries shall be supplied in factory filled and charged condition.

29.22.3.8 **WATER**

Water required for preparation of electrolyte shall conform to IS: I069.

29.22.3.9. **PLATE CONNECTION**

Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be caste with lead alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

29.22.3.10 **BOLTS AND NUTS**

Nuts and Bolts for connecting the cells shall be of superior grade passivated Stainless steel.

29.22.3.11 **TERMINALS**

Terminals shall be of integral lead terminal with solid copper core with M6 threading for fastening. The junction between terminal posts and cover and between the cover and container shall be hermetically sealed

29.22.3.12 **BATTERY RACKS** ...

Batteries shall be installed on MS racks to be supplied by the Contractor to fit in the battery room. Racks/Trays shall be powder coated with anti-corrosive paint. Rack shall accommodate 55 cells plus 2 spares. Racks/Tray shall be suitably treated before painting for protection against fungus growth and other harmful effects due to tropical environment. The colour of the supporting racks shall conform to RAL 7032 shade.

29.22.3.13 CAPACITY REQUIREMENTS:

When the battery is discharged at 10 hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs upto 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

The capacity (corrected at 27°C) shall also not be less that Rated capacity & not more that 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

(a) After SIX hours of discharge: 1.92V/cell
(b) After EIGHT hours of discharge: 1.85V/cell
(c) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt-hour efficiency shall be better than 80%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from the date of installation. Date of initial charging is to be mentioned on the battery.

29.22.3.14 ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery) :

a) Best quality metallic stand/frame as per Clause 9.12.
b) Stand insulators +5% extra
c) Inter row connectors :Appropriate quantity
d) Inter tier connectors
e) Centre-zero (3-0-3) volts DC Voltmeter : 1 No
f) Torque wrench/ Spanners : 1 No
g) Connection hardwares, such as strips, bolts, nuts(with 5% extra)
h) Cable clamps with hardware
i) Cell numbering tags with fixing arrangement
j) Two sets of special tools and tackles for connecting terminals of the battery
k) Any other accessories not specified but required for satisfactory operation.

29.22.3.15 TYPE TEST OF BATTERY:

The Tenderer/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the range of at least one capacity per design. The Tenderer/ Supplier shall submit necessary evidences enclosed along with tender documents.

Sl No	DESCRIPTION
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification
8	Valve Operation

9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge for reliable mains power
14	Recharge behaviour
15	Service Life at an operating temperature of 40°C for brief duration exposure time
16	Impact of Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge
18	Thermal Runaway Sensitivity
19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installation

29.22.3.16 Routine Test:

(i) Physical Examination Test
(ii) Visual Inspection
(iii) Dimensions, Mass & Layout
(iv) Marking & Packing

29.22.3.17 ACCEPTANCE TEST OF BATTERY

(i) Polarity Marking
(ii) Verification of Dimensions
(iii) Open Circuit Voltage of each Cell & Total Open Circuit voltage of the battery bank
(iv) Test of AH Capacity

29.22.3.18 LIST OF FACTORY & SITE TESTS FOR BATTERY

Sl. No.	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load	YES	

29.22.4 48V BATTERY CHARGER

29.22.4.1 General:

This section covers the general requirement of 48 V DC SMPS Based Power Plants, based on High Frequency Switch Mode Techniques using switching frequencies of 20KHz and above for use in AEGCL.

29.22.4.2 SMPS Based Power Plants is intended to be used in **Auto Dual Float Rectifier cum Boost Charger (FR-BC)** mode as a regulated DC Power Source.

29.22.4.3 **Power System Configuration**:

The configuration of 48 V DC Power Plants with FR-FC & FRBC Modules shall be as under:

Sl No	Basic SMR Module	Configuration	Permissible Ultimate Capacity
1	25 A FR-FC	(n+1)	75 Amp
2	50 A FR-FC	(n+1)	150 Amp
3	25 A FR-BC	(n+2)	75 Amp
4	50 A FR-BC	(n+2)	150 Amp

The FR-FC or FR-BC modules shall be housed in (n+1) or (n+2) parallel configuration in a single rack where 'n' is the actual required number of FR-FC, FR-BC modules for meeting the particular load requirement.

AEGCL shall indicate the Type, Number and Configuration of SMR Modules, depending upon the load requirement. AEGCL shall also indicate Ultimate Expandable Capacity considering future expansion requirement.

29.22.4.4. The Battery Charger of 48V/25A (Ultimate capacity 150A) or 48/50A (Ultimate capacity 150A) N+1 configuration shall be of SMPS type and shall be chosen as per load demand of communication equipments of the substations. The system shall consist of DSA and Float Rectifier –cum-Charger (FR/FC) in a steel rack in a modular type. It should have menu driven microprocessor control technique for DSA as well as module for control, monitoring and alarm to achieve better reliability of the system.

29.22.4.5 **Rack Configuration :**

Rack is composed of following units accommodated in sub racks

a) Dual Float Rectifier cum Boost Charger (FR-BC) Modules.
b) Distribution-Switching-Control-Alarm Arrangement (DSCA)
c) The number and rating of FR-FC, FR-BC Modules shall be provided as per purchaser's requirement. The Distribution-Switching-Control-Alarm Arrangement (DSCA) shall be provided for the Ultimate Expandable Capacity. All factory wirings for the rack shall be for the Ultimate Expandable Capacity so that only plugging-in of FR-FC or FR-BC module shall enhance the DC Power output.

29.22.4.6 **Parts & Components**

The Parts & Components including Fuses and Circuit Breakers for manufacturing of the SMPS Based Power Plants shall be of Industrial Grade. These Parts & Components shall be procured from reputed manufacturers to ensure prompt and continuous service and delivery of spare parts.

Power Transformers and Chokes shall use Class B or Higher Grade of insulation. The Transformers and Chokes shall be wound with copper wire provided with adequate insulation.

Component mounting and fixing methods shall be secured.

29.22.4.7 **Wiring:**

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current voltage during fault and overload.

All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of Metal Panel or Cover, the hole through which they pass shall be suitably bushed with rubber grommet.

29.22.4.8 **Bus Bars:**

Bus bars shall be of high conductivity electrolytic copper strips capable to with-stand 1.5 times the maximum load current. The Bus bar shall be capable to carry current density of 2 Amps/mm2 but shall not be less than 25mmx5mm in any case. The size of bus bars chosen for battery and load path shall be capable to take care of the current of maximum power plant capacity for which it is designed.

Bus-bar Riser height wherever applicable shall be 250mm for both load and battery.

Earthing: All non-current carrying metal parts shall be bonded together and earthed. An earth terminal suitable for taking minimum 4 mm dia wire and with suitable marking shall be provided

The SMPS Based Power Plants shall be designed & manufactured for continuous operation at rated load in the ambient temperature range of 0ºC to 55ºC.

Insulation Resistance and Voltage Proof

The insulation resistance of a fully wired FR-FC and FR-BC Modules when tested with a 500V DC Megger shall be as given below:

a) AC input and Earth - Greater than 2 Mega Ohm
b) DC Output and Earth - Greater than 1 Mega Ohm
c) AC input and DC output - Greater than 5 Mega Ohm.

29.22.4.9 **Lightning Protection :**

The SMPS Based Power Plants shall have modular type Type I/Class B and Type II/Class C type surge protection in TT configuration of wiring. Both the Type I/Class B and Type II/Class C arrestors should be from the same manufacture and shall be mounted as per the specific installation recommendations of the manufacturer to achieve perfect coordination.

Radio Frequency Interference Suppression: The module shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by Switch Mode Power Conversion Equipment operating within the rack.

29.22.4.10 **Name plate :**

A name plat etched/engraved/anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each rack/module and contain following information.

1. Specification Number
2. Type of Unit
3. Manufacturer's name and identification
4. Model No.
5. Unit Serial No.
6. Input Voltage and phase
7. Output Voltage and current
8. Year of manufacture
9. Suitable for battery capacity

29.22.4.11 AC input supply: The Power Plant using FR-FC or FR-BC modules of 25 Amps shall operate from single phase AC input and FR-FC or FR-BC modules of 50A capacity may operate from single phase or 3 phase 4 wire AC input. The nominal input frequency is 50Hz which may vary from 48-52Hz. The input voltage range shall be as given below:

a) Single Phase (nominal 230V) :

For Power Plant to be used at stations having reasonable power supply regulation, incoming power supply range shall be from 165 V AC to 260 V AC.

b) Three Phase/4 Wire 400V+10%/ - 15% (Nominal 400V)

29.22.4.12 There shall be an automatic arrangement for shutting off the FR-FC or FR-BC Modules wherever the input voltage is beyond the specified operating limits with suitable alarm indication. It shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the FR-FC or FR-BC Modules. A tolerance of ±5V may be acceptable for protection & alarm operation. All the FR-FC or FR-BC Modules shall switch OFF simultaneously.

29.22.4.13 FR-FC or FR-BC Modules working from 3 phase/4 wire input shall work satisfactorily for unbalance of ±10% of nominal input. The module shall be isolated (if required for the protection of the unit) in the event of unbalance beyond 10% and shall restore when the input is within limits.

29.22.4.14 The SMPS battery charger shall be capable of continuous operation with float voltage 2.23 to 2.25 Volt per cell and 2.3 Volt per cell for charge voltage while supplying the constant DC load.

29.22.4.15 The SMPS battery charger shall have constant voltage characteristics throughout the range (from zero to full load) at floating value of the voltage so as to keep the VRLA batteries fully charged but without harmful overcharge.

29.22.4.16. The float cum boost charger works on 415 V AC, 50 Hz supply (or 230 V AC, 50 Hz supply). The battery charger should be capable of delivering the full rated load at the specified voltage at the output terminals. The set output voltage is maintained for AC input variation of + 10% and load variation from 0-100% of rated full load.

29.22.4.17 The charger voltage in float mode of operation is normally be set at 54 V DC and the same shall be adjustable between 48 and 54 V DC through variable potentiometer. When the charger is selected to boost mode, it should supply charging at the rated current maximum. This shall be adjusted from 20% to 100% of rated current through potentiometer.

29.22.4.18 All these circuits are housed in freestanding cabinet of folded sheet steel (thickness of sheet steel should not be less than 2.5mm) construction finished in stove enamel light gray colour conforming to shade of 631 of IS: 5. The cabinet is provided with front and back doors for easy accessibility. All meters, meter selector switches, control switches and LCD display (Microprocessor unit) etc are to be provided on the front panel. The AC input and DC output MCCB'S and control switches are provided on middle inside of the breaker panel. The cable terminations are provided on front side of the cubicles.

29.22.4.19 PARTICULARS

Type	FLOAT CUM BOOST CHARGER Hot swappable rectifier modules 25A/48V, N+1 configuration.		
Rating	48 V (Capacity as per Battery Sizing Calculation) Dual float cum boost charger (suitable for MF-VRLA battery)		
AC INPUT			
A	Voltage	415 V AC+ 10% (230V AC +10%)	
B	Phase	3 phase, 3 wire (single phase)	
C	Frequency	50 Hz+5% (50Hz+2Hz)	
D	Power factor	(Better than 0.7 lagging)	
DC OUTPUT			
A	Float voltage	:	48 V- 54 V DC
B	Boost voltage	:	48 V-55.2 V DC
C	Output current	:	35A
D	Voltage regulation	:	Better than + 1% of set value
E	Ripple	:	Less than 1% r m s
F	Efficiency	:	(Better than 90%)
G	System output voltage	:	55.2V DC+1%(at load terminal)
METERS		The microprocessor based controller should have metering facilities namely (a) Load Voltage (b) Load Current, (c) Battery Voltage (d) Battery Current (e) Battery Temperature, (f) Voltage and current of individual module.	
PROTECTION			
Over voltage trip at the output	:	Over voltage cutback	56.5+ 0.5 V DC
DC under voltage at battery input	:		42+ 0.5 V(1.75 V X 24)
Fuse at AC input	:	Fast acting semiconductor fuse	Fast acting semiconductor fuse
Fuse at DC out put to load	:	MCCB	Fast acting semiconductor fuse
Reverse polarity at battery input	:	Protected	Protected
Out put current limiting	:		Battery charging current limit
AC input MCCB	:	Required	Required
Blocking diode	:	Required	Required
Charger over load	:	Required	Required

INDICATION		
AC input ON	:	Required
DC output ON	:	Required
Float ON	:	Required
Boost ON	:	Required
AC under voltage	:	Required
AC over voltage	:	Required
DC over load	:	Required
DC over voltage	:	Required
Short circuit	:	Required
Reverse polarity	:	Required
Mains fail		Required
Charger fuse fail		Required
Battery over voltage		Required

CONTROLS AND SWITCHES	
AC input MCCB	ON/OFF switch at input

DC output MCCB	Three way switch to select auto / manual float / manual boost operation
Auto/manual float/boost mode selector switch	Two way switch to read charger output current or battery charge / discharge current
Auto /manual voltage regulator selector switch	Single tern potentiometer for float voltage adjust
Float and boost voltage variable potentiometer	Single tern potentiometer for boost voltage adjust
Manual voltage adjust variable potentiometer	Single tern potentiometer for charger total current adjust
Battery current adjust potentiometer	Single tern potentiometer for battery current adjust
Heaters power supply switch	
Socket power supply switch	
ADDTIONAL FEATURES	
Soft start on DC side	Auto float / boost operation

29.22.4.20

a). The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement.

b). The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

29.22.5 Power Distribution and Protection

The Employer will furnish only one source primary 240 VAC. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and 48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.

The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

29.23.0 Equipment Construction, Assembly and Installation

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

2.23.1 Identification

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

2.23.2 Equipment

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the

Contractor has complied with all requirements of this specification. Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification. Equipment chassis and printed circuit card cages having wired back-planes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

2.23.3 Power Distribution

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity.

Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with aunique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door.

Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.

All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the Contractor's power cable plant drawings.

2.23.4 Signal Cabling

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.

Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fanout point.

All signal cable, wiring and terminations shall be clearly labelled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

2.23.5 Equipment Racks and Enclosures

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labelled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

2.24.0 Installation Hardware

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

2.24.1 Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in sub-racks andcabinets (enclosures). The Contractor shall determine and propose for the Employer approval, thetype, size, weight and manner of installation for each location.Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

(A) Equipment Sub Rack Construction

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

(1) Equipment Sub Racks shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.

(3) Dust and moisture protection shall meet or exceed IP20 standards.

(B) Equipment Cabinet (Enclosure) Construction

(1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to

obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.

(3) All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.

(4) Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

29.24.2 Cable Raceways

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

(1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.

(2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.

(4) Outdoor 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 taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

(5) Indoor cable raceways fabricated of aluminium or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

29.24.3 Signalling Distribution

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

(1) All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.

(2) The Contractor shall provide subscriber level wiring and patching wherever required.

29.24.4 Lightning and Transient Voltage Protection

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

(1) At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.

(2) All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

29.24.5 Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

(1) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards.

(2) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.

(3) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sq mm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis

utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.

(4) The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.

(5) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required.

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer's approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

29.25.0 Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor supplied as-built drawings.

The Contractor shall supply and install all primary power cords, power-strips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

29.26.0 Finish Colors

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

29.27.0 Location of Equipment, Cable Routes and Associated Civil Works

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment
siting, intra and inter facility interconnectivity and necessary associated civil works.

29.27.1 Locations for Supplied Equipment

All transmission equipment and associated DDFs, shall generally be co-located in the same communications room located in the Control Building whenever possible.

29.29 Inspection, Test and Availability

i) 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.

ii) Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, 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.

iii) 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/Employer's representative.

iv) Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

v) All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

vi) 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.

vii) 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. All security related features shall be demonstrated during FAT/SAT as required by the Employer.

29.29.1 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 labeling. 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.

29.29.2 Test Plans and Procedures

a) 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.

b) The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test

c) 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.

d) 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.

29.29.3 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for 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 4-1.

Table 4-1

Factory & field Test Plan Requirements

Items	Description
1	Test Schedule
2	Record-keeping assignments, procedures and forms
3	Procedures for monitoring, correcting and retesting variances
4	Procedure for controlling and documenting all changes made to the communications equipment after the start of testing.

29.29.4 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. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 4-2.

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/ jig 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 4-2
Test Procedure Requirements

Item:	Description:
1	Test Title and Revision Level, if applicable
2	List of Standard(s) complied with
3	Function(s) / parameter(s) to be tested
4	Purpose of each test segment
5	List of required test equipment
6	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.
7	Test setup including test configuration block diagrams and/or illustrations.
8	Test procedures to be followed.
9	Required inputs and expected outputs for each test segment
10	Acceptance criteria for each test segment.
11	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
12	Format of test reports.

29.29.5 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 4-3.

Table 4-3
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	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 the specified duration after the 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.

29.29.6 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.

29.30.0 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All 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 five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer’s representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

(g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

29.30.1 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected a random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

29.30.2 List of Type Tests

The type testing shall be conducted on the following equipment

(a) SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)

29.30.2.1 List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop- Insert Mux with subscriber interface card and DACS are described below:

29.30.2.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

(a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.
(2) Degree of Severity: Test shall be done at 0°C
(3) Acceptance Criteria: No degradation of performance during and after the test.

(b) Low Temperature Test : Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*)

(2) Degree of Severity: Test shall be done at -10° C

(3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours.
(2) Degree of Severity: As per table 5-1: operation to specification range.
(3) Acceptance Criteria: No degradation of performance during and after the test.

(d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at 55ºC.

(3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

(2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

(f)Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

(1) Number of cycles required is five (5)
(2) The degree of severity: temperature TL:0°C, TH: As per table 5-1 (Operation to specification range)
(3) Cycle duration for each temperature is three (3) hours.
(4) Ramp : 1 oC/minute.
(5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

29.30.2.2 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.
Immunity Tests
The list of Immunity tests are specified below in Table 4-4:

Table 4-4: Recommended Immunity Tests

Sl No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-1: 1995 - **Level : 1**
2	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	
3	100/1300 µs surge	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995
4	1.2/50 - 8/20 µs surges	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995 - **Level : 4**
5	Fast transient bursts	Yes	Yes	Yes	N/A	

Sl No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
6	Damped oscillatory waves	Yes	Yes	Yes	Yes	
7	10/700 µs surges	**N/A**	**N/A**	**N/A**	**Yes**	
8	Electrostatic discharge	**Yes**				Table 13 of IEC 60870-2-1: 1995 - **Level : 4**
9	Power frequency magnetic field	**Yes**				Table 14 of IEC 60870-2-1: 1995 - **Level : 4**
10	Damped oscillatory magnetic field	**Yes**				
11	Radiated electromagnetic field	**Yes**				Table 15 of IEC 60870-2-1: 1995 - **Level : 4**
12	Power Frequency voltage on control and signal lines	**N/A**	**N/A**	**Yes**	**Yes**	IEC 61000-4-16 : 2002-07 **Level : 4**
13	DC voltage on control and signal lines	**N/A**	**N/A**	**Yes**	**N/A**	IEC 61000-4-16 : 2002-07 **Level : 4**

(a) Emission Tests:

The list of Emission tests are specified below in Table 4-5

Table 4-5:
Recommended Emission Tests

S. NO.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	LF disturbance voltages CCITT Recommendation P.53	N/A	Yes	N/A	N/A	Table 17 of IEC 60870-2-1: 1995 - Class **: B**
2	Transient disturbance voltages	Yes	Yes	N/A	N/A	
3	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
4	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
5	RF radiated fields CISPR 22	**Yes**				

(c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class : VW1 of Table 18.

29.30.2.3 Mechanical Tests

(a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements. Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semisinusoidal shape (clause 3.1.1.2).

The recommended severity shall be A = 294 m/s^2, D = 18 ms. Three shocks per axis per direction shall be applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

29.30.2.4 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, DACS, associated Subscriber Line Interface Cards etc), Network Management System etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment 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 Employer 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 equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

29.30.2.5 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 minimum 10% of the batch size (minimum 1) for all 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. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

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.

29.30.2.6 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), along-with information such as sampling frequency, applicable standards, acceptance criteria etc.

Table 4-6:
Factory Acceptance Testing for Fibre Optic Transmission System

Item	Description
1	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2	Optical output power
3	Transmitter lightwave spectral analysis
4	Low receive level threshold
5	Generation of bit error rate curve
6	Measurement of analog and digital service channel parameters as well as service channel functionality
7	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
8	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers
9	At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
10	Simulation of failure conditions and failover of each redundant unit.
11	Test of spare card slots
12	Checks of power supply/converter voltage margins
13	Random inspections to verify the accuracy of documentation
14	Test of spare parts/modules/cards as per applicable tests

2.30.2.7 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & 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. At a minimum Site Acceptance Testing requirement for Telecom equipment, NMS etc. 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 Telecom equipment 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.

29.30.2.8 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

29.30.2.9 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense. In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated. The minimal installation testing requirements for fiber optic transmission subsystem, Termination equipment sub-system and NMS are provided in respective Tables in this section.

29.30.2.10 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:

a) Ping test
b) Throughput test
c) Latency test
d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations used)
shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects. This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

29.30.2.11 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the channels required to interconnect the various User's interfaces. The integrated testing for batch shall include end-to-end testing of back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire backbone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

(1) Equipment configuration shall be checked to establish that it supports the channel routing.
(2) Testing of Craft Terminal to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault, Management and Security management. All the standard features of the Craft Terminal based NMS shall be demonstrated for proper functioning.
(3) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Table 4-7
Fibre Optic Transmission system Installation Testing

Item	Description
1	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
3	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4	Service channel performance
5	Craftsperson interface, alarm and control functional performance
6	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
7	Network management interface and supervision performance
8	Correct configuration, level setting & adjustments and termination of Input/output interfaces
9	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10	Simulation of failure conditions and failover of protected components.

29.31 Training and Support Services

This section describes the requirements for Contractor-supplied training, support services, and maintenance of the FOTS. The intent of the training and support program is to ensure a smooth transfer of systems and technologies from the Contractor to the Employer, and to ensure that Employer staff is fully trained to operate, maintain and expand the integrated telecommunication network.

29.31.1 Training

The Contractor shall provide a comprehensive training program that prepares the Employer's personnel for on-site installation support, operation, and maintenance of the telecommunication network.

Training may be conducted by the Contractor, the Contractor's subcontractors, and/or original equipment manufacturers (OEMs). The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English and who are experienced in instruction. All necessary training material shall be provided by the Contractor. The training charges quoted by the Contractor shall include training materials and all associated expenses. However, for all training courses in India or abroad, the travel (e.g., airfare) and per diem expenses covering fooding and Lodging of the participants will be borne by the Contractor. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangement.

Hands-on training shall be provided with equipment 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.

29.31.2 System Design & Overview Training

This training shall provide a functional description of the fibre optic transmission system and a discussion of the failover and alternate routing schemes inherent in the configuration. The

training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software. The training shall highlight all significant methodologies or concepts utilized by the hardware and software to perform the required functions. High-level hardware configuration block diagrams and network/sub-network block/flow diagrams shall be included to enhance the understanding of the overall capability incorporated into all network and sub-network equipment.

The training shall be oriented to a user's point of view. The Employer/Owner users will include managers, design & planning personnel, communication support staff and maintenance personnel. As part of the proposal, the Contractor shall identify the number of days deemed appropriate for this training.

The overview training shall be customized for the specific functions, features, and equipment purchased by the Employer; it shall not be a general presentation of the Contractor' 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.

29.31.3 Installation & Maintenance Training

There shall be separate modules of the installation & maintenance training for the FO Transmission System.

The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive &

restorative maintenance of the respective communications subsystems purchased by the Employer. **In addition to that the Bidder shall provide Video Tutorials or necessary documentation for maintenance and trouble shooting.**

29.31.4 Network Management Training

The Network Management training shall familiarize the Employer's telecommunication personnel with the concepts and techniques for configuring, programming, maintaining, and troubleshooting the Contractor supplied NMS and its associated database. The Network Management training course shall provide the course participants with hands-on experience using the actual system being supplied.

29.31.5 Training Course Requirements

This section describes general requirements that apply to all training courses

29.31.5.1 Class Size

The Employer plans to send a number of participants to the training courses for a specified duration as described in Appendices.

29.31.5.2 Training Schedule

The Contractor shall provide training in a timely manner that is appropriate to the overall project schedule. All training courses shall be available to the Employer for a minimum of five years after final acceptance of the communication system. The training courses shall be offered in one cycle, such that none of the courses within the cycle overlap. The Contractor shall take the above requirements into account in developing the preliminary training schedule. Contractor shall develop a final training schedule in consultation with the Employer after contract award.

29.31.5.3 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 classroom instruction. 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 the master and two additional copies of all training manuals and materials as reference documentation. A complete set of instructor's manuals and training aids shall also be provided. 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 for use in the Employer-conducted training courses. The Contractor shall furnish for use during training courses all special tools, equipment, training aids, and any other materials required to train course participants.

29.32 Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required. The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test. After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. However the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

29.32.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above

29.32.2 Contractor's Future Hardware/Software Changes

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made to supply equipment. The service shall begin at the time of contract award, and shall continue for 10 years. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

29.32.3 Spare Parts and Test Equipment

The spare parts and test equipment shall be provided for each subsystem as described below.

29.33 Mandatory Spare Parts

Appendices provides the Mandatory Spare Parts Requirements described in **subsystem sets**. The mandatory spare parts table represents the minimum spares the Contractor shall be required to supply. The **subsystem set** of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem.

29.33.1 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipments are enumerated in Table 6.2 below and shall be as per the Chapter “spares and tools”

Table 6.2

Sl. No.	Test equipment	
	SDH Analyser	
	Handheld 2Mbps BER Tester	
	Digital Multimeter	
	Ethernet Tester (with dual port, 10/100 ports Mbps Ethernet option, layer-1 & layer-2 functionality)	

In case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for

use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment
from at least one customer.

The Contractor shall provide in their bid, additionally recommended test equipment list necessary to support system availability figures specified in technical specifications. These lists shall include all relevant technical descriptions and recommended minimum quantities based upon the guidelines consistent with the telecommunications resource management hierarchy and continuing maintenance concept. The recommended test equipment shall not be considered for evaluation and may be included in the final scope of supply.

29.34 System Maintenance

As per DoT guidelines, operation and maintenance of the network shall be entirely by Indian engineers and dependence on foreign engineers shall be minimal within a period of two years from the date of LoA. The contractor shall be responsible to maintain the confidentiality of the Employer's System Information that Employer shares with the contractor for maintenance period.

29.34.1 Warranty Period

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under Vol I Condition of Contracts during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System supplied under this Package. The specification for the maintenance of the system after Operational Acceptance is enclosed at Annexure-I.

29.34.2 Contractor's Maintenance Responsibility

The Contractor shall be responsible for carrying out "Non-Comprehensive Maintenance" of the Communication System for a period of six years after warranty period for ensuring the successful operation of the system. The Contractor shall be responsible for achieving the system availability and the response time mentioned in technical specifications. The tenderer shall quote the Annual Maintenance Charges for six years after Warranty Period which shall be considered in the bid evaluation. Tenderer shall submit the detailed procedure for achieving above in the bid. The specification for the maintenance of the system is enclosed at Annexure-I. Upon expiry of the six years AMC period Employer may, at its discretion, extend this Maintenance for additional one year at the same price & terms and conditions.

29.34.3 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

29.35 Documentation

The Contractor shall submit following documents during detailed engineering:

(a) Data Requirement sheets
(b) Link Budget calculations
(c) MQP, FQP
(d) Bill of Quantity including mandatory spares
(e) Previous Type test reports
(f) Factory Test report
(g) Manuals for each equipment
(h) Schematic drawing
(i) Numbering, Marking, labelling document
(j) Synchronization plan
(k) Test schedule
(l) Training manual
(m) Configuration diagram
(n) Transportation & handling Procedure

(o) Installation Manuals
(p) Maintenance Manual

APPENDIX-D

BILL OF QUANTITIES OF FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT (REFER PRICE SCHEDULE FOR BOQ FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT)

APPENDIX-E
(The following data shall be furnished for each of the manufacturer)
DRS Form 01
DATA REQUIREMENTS SHEETS for
OPTICAL LINE TERMINATION EQUIPMENT (OLTE)

GENERAL OLTE FEATURES

Sl No	Parameter:	As per Technical Specification	As per Tenderer Offering
1	SDH hierarchy level: Capacity Aggregate Bit-rate: CEPT E-1 Ports: SDH Heirarchy Level: STM-16	STM-16 620 Mbps 252 x E1	
2	Minimum No. of protected (MSP) directions	Five	
3	No. of E1 ports in E1 tributary Cards	minimum 63	
4	No. of ethernet ports in Ethernet interface tributary cards	minimum 8	
5	Service Channel provision a) Voice Channel b) Data Channel	Yes Minimum 8 Minimum 4	
6	Power Supply cards of SDH Equipment Common Control* Card of SDH equipment	1:1 APS 1:1 APS	

GUARANTEED TECHNICAL PARTICULARS FOR VALVE REGULATED LEAD ACID BATTERY

(To be filled in and signed by the Tenderer)

1	Type/ Designation	48V, 200AH battery bank
2	Manufacturer's type designation	
3	Ampere-Hour capacity 10hrs rate of discharge to 1.75V	
4	Total No. of Plates per cell	
5	Nominal Cell Voltage (V)	
6	No. of Cells in each Bank	
7	No. of Spare Cell, if any, in each Bank	
8	Internal Resistance for each Cell	
9	Resistance of the Battery including Inter-connection between the Cells	
10	Cell Discharge rate in Ampere (from rated Voltage to final discharge rate in Ampere (i) 5hrs Discharge rate in Amp (ii) 2hrs Discharge rate in Amp (iii) 1hr Discharge rate in Amp (iv) 30min Discharge rate in Amp (v) 10min Discharge rate in Amp (vi) 1min Discharge rate in Amp (vii) 30sec Discharge rate in Amp (viii) 1sec Discharge rate in Amp (Please furnish a graph showing Amps against time for the type of battery offered)	
11	Short Circuit Current (Amps)	
12	(i) Material of Cell Containers (ii) Material used for Battery Box (iii) Trays	
13	Thickness, Type & Material of Separators	
14	Constructional details and dimension: Surface area plates of (i) Positive Plate (ii) Negative Plate in Sq.mm.	
15	(i) Ampere Hour efficiency (%) (ii) Watt Hour efficiency (%)	
16	(i) Recommended Float Charge Current & Voltage (ii) Recommended Boost Charge Current & Voltage	
17	Time required for Boost Charging from Discharged condition	
18	(i) Max. Charging Current/Cell (ii) Nominal Charging Rate	
19	(i) Whether explosion proof or vent plugs provided (ii) Whether vent is spill proof	
20	Type of Inter Cell connection & whether they are covered with plastic sleeves	
21	(i) Dimensions of each 2V Block/Cell a. Length (mm) b. Width (mm) c. Height (mm) (ii) Thickness of Container (mm)	

APPENDIX-A

Table A-1

Typical transmission line details (To be filled by the Bidder)

Line Voltage	S/C or D/C	Nominal Span (E/W & Conductors in mtrs.)	Wind Zone as per IS 802	Design Tension at Every Day Temp (32º C) and full wind condition – OPGW) in kg	Wind Pressure (kg/Sq-m) considering gust factor	Max Sag – Ground Wire at 53ºC (in mtrs)	UTS – OPGW (in Kg)	Weight – Earth wire (in Kg/km)	Minimum Clearance in mtrs.		
									A1	B1	C1
400KV	S/C										
	D/C										
220 KV	S/C										
	D/C										
132 KV	S/C										
	D/C										

A1 Minimum clearance between conductor and ground (in meters)

B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.

C1 Minimum clearance between conductor and earth wire (in meters)

SECTION- 8

SCHEDULES

SCHEDULE - I

GUARANTEED PARTICULARS FOR POWER CONDUCTOR

(To be filled in by the bidder and submitted as part of Bidding Schedules)

Sl. No	DESCRIPTION	PARTICULARS
1.0	Name of manufacturer and address for: (a) Aluminium Alloy rods: (b) Aluminium Alloy Conductor:	
2.0	Applicable Standard for: (a) Aluminium Alloy rods: (b) Aluminium Alloy Conductor:	
3.0	No of Strand x Size, (No. x mm)	
4.0	Conductor over all diameter, (mm)	
5.0	Total sectional area, (mm^2)	
6.0	Approx. weight, (kg/kM)	
7.0	Minimum UTS, (kN)	
8.0	Modulus of Elasticity (Final), (kg/cm^2)	
9.0	Coefficient of linear expansion, (per^0C)	
10.0	Calculated maximum resistance of Conductor at 20°C, (ohm/Km)	
11.0	Lay Ratio: (i) 6 wire layer (max/min) (ii) 12 wire layer (max/min) (iii) 18 wire layer (max/min)	
12.0	Particulars of Aluminium Alloy Wires (strands)	
	(a) Wire Diameter, (mm) (i) Standard: (ii) Maximum: (iii) Minimum:	
	(b) Resistivity of wire, ($ohms.mm^2/m$)	
	(c) Density	
	(d) Co-efficient of Linear expansion (per^0C)	
	(e) Cross Sectional area of Aluminium wire	
	(f) Approximate Total weight of each strand, (kg/km)	
	(g) Calculated resistance at 20°C (D.C.), (ohms/km)	
	(h) Minimum Breaking Load of each strand, (kN)	
	(i) Minimum elongation on a gauge length of 200 mm	

SCHEDULE – II

GUARANTEED PARTICULARS AND MANUFACTURING DATA

(FOR INSULATORS, AND HARDWARE EFC.)

(To be filled in by the Bidder)

Sl. No.	Description	Particulars
1.	INSULATORS AND ACCESSORIES	
	(i) Name of manufacturer, Country of Origin for: a) Insulator Disc b) Insulator Hard ware c) Accessories	
	(ii) Size of the Insulator Disc a) Outside diameter of the disc, mm b) Height of the Disc, mm c) Pin ball shank diameter, mm d) Size of ball and socket and the Standard to which it conform.	
	(iii) Particulars of single Disc:- a) Electromechanical Strength, KN b) Minimum failing load, KN c) Dry flashover voltage, KV d) Wet flashover voltage, KV. e) Puncture Voltage, KV f) Weight, Kg.	

Sl. No.	Description	Particulars
	(iv) Particulars of Insulators String: a) Breaking Strength, KN b) Low frequency flashover voltage without arching horn > Dry, KV > wet, KV c) Low frequency flashover voltage without horn > Dry, KV > Wet, KV d) Dry impulse flashover voltage using standard 1.2/50 micro second impulse: > without arching horn, KV > with arching horn on line side only, KV > with arching horn on both line and tower sides, KV e) Low frequency test voltage with arching horn > on line side only, KV > on both line and tower sides, KV f) Dry impulse test voltage using standard 1.2/50 micro second impulse: > without arching horn, KV > with arching horn on line side only, KV > with arching horn on both line and tower sides, KV g) Corona formation voltage with normal fittings, KV h) Breaking Strength of > Suspension Clamps, KN > Tension Clamps, KN h) Slipping Strength of > Suspension Clamps, KN > Tension Clamps, KN	