SECTION: EHV XLPE POWER CABLE

1 CABLE CONSTRUCTION DETAILS

1.1 The XLPE insulated EHV cable shall conform to the requirements of IEC 60502-2 (applicable clauses only) for construction and IEC 60840/IEC 62067 (as applicable) for testing. The terminating accessories shall conform to IEC 60840/ IEC 62067 (as applicable). The offered cables and its terminating accessories shall be compatible with each other.

1.2 The EHV grade cable shall be single core, unarmoured, stranded, compacted/ Segmental **Aluminium/Copper (as specified in BPS)** conductor, core screening by a layer of semiconducting tape followed by a layer of semiconducting compound, cross linked polyethylene (XLPE) dry cured insulation, insulation screening with semiconducting compound extruded directly over the insulation, longitudinal sealing by a layer of non woven tape with water swellable absorbent over insulation screen, followed by radial sealing (Metal sheath of Lead alloy 'E' / **Corrugated Aluminium, (unless otherwise specified in Section Project)**, metallic screening by concentric layer of plain copper wire (as required) to meet short time current requirement, & overall HDPE sheathed & graphite coated and conforming to the technical particulars of specification. Bidder may offer necessary layers such as separation tape, binder tapes etc additionally as per their manufacturing practices for meeting type/additional test requirements for offered cables.

1.3 The cable shall be suitable for laying under the climate conditions as specified in Section-Project in underground buried trench/duct etc. installations with uncontrolled back fill and chances of flooding by water.

1.4 Cable shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions.

1.5 Progressive sequential marking of the cable length (in metres), at every one metre, shall be provided on the outer sheath of the cable.

1.6 Repaired cables shall not be accepted.

1.7 Allowable tolerance on the overall diameter of the cables shall be ± 2 mm.

1.8 CONDUCTOR

The conductor shall be of Copper/Aluminium wires as specified in the **Bid Price Schedule (BPS)**. The shape of conductor shall be compacted /segmental having high compactness and smooth surface finish.

1.9 CONDUCTOR SCREEN

The conductor screen shall consist of extruded semi-conducting layer. Semi-conducting separator tapes shall be applied between conductor and the extruded semi-conductor layer. The conductors screen (non-metallic semi-conductive)

shall be extruded in a single one-time process to ensure homogeneity and absence of voids.

1.10 INSULATION

The extruded XLPE insulation shall be applied over the conductor screen to the desired thickness in a void free manner.

1.11 INSULATION SCREEN

The insulation screen shall consist of extruded semi-conducting Layer. Suitable bedding tapes shall be applied over the extruded semi-conducting Layer.

1.12 MOISTURE BARRIER

Longitudinal water barrier:
The longitudinal water barrier shall be applied over insulation screen by a layer of non woven synthetic tape with suitable water swellable absorbent.

Radial Moisture Barrier:
This shall be of extruded Lead alloy "E" sheath or **Corrugated Aluminium sheath unless otherwise specified in Section Project. In case Corrugated Aluminium sheath is used, suitable anti-corrosive layer shall be applied over the Aluminium sheath.**

1.13 METALLIC SCREEN (AS REQUIRED):

The metallic screen shall be of plain copper wires, helically applied over the radial moisture barrier. A suitable binder tape of annealed plain copper shall be applied over the copper wire screen. The combination of the metallic sheath (lead or Aluminium sheath) in combination with wire screen shall be designed to meet the requirement of the system short circuit rating as specified in **the bidding documents**.

1.14 OUTER SHEATH

The outer sheath shall consist of extruded black coloured HDPE with graphite coating. The outer sheath shall be suitably designed by the addition of chemicals in the outer sheath for protection against termite and rodent attack and shall be coated with graphite to facilitate sheath integrity test during manufacturing and post installation as per IEC 60229.

1.15 RATING

The contractor/ manufacturer shall declare current rating of cable for maximum conductor temperature of 90 degree C under continuous operation and 250 degree C during short-circuit condition. The contractor/ manufacturer shall also declare over load curve with duration for conductor temperature of 105 Deg C. A complete set of calculation made in arriving at the current rating shall be

furnished, for laying condition envisaged under the project, during detailed engineering for Employer/Owner's reference.

1.16 CABLE JOINTING ACCESSORIES

1.16.1 The cable jointing accessories shall include all the straight through joints, Cross bonding, earth continuity cables, Link boxes, Sheath Voltage Limiters (SVLs) etc as required for entire cable route. Bidder shall arrange all special tools and tackles required for making these joints at his own cost. Unless specified separately in BPS, cable end terminating kits shall be deemed included as part of cable jointing accessories.

1.16.2 The straight through joint shall preferably be built up from the same material as the main cable and shall have electrical and mechanical withstand capabilities same as or better than the main cable. The joints shall be suitable for Climate conditions as specified in Section-Project.

1.16.3 The straight through joints and cable end terminations shall be of proven design and should have been type tested as per relevant IEC. A list of supply of cable jointing accessories shall be furnished.

1.16.4 The detailed description on jointing procedure shall be furnished during detailed engineering.

1.16.5 The cable end terminations shall be of anti-fog type and shall be of Polymer type/Porcelain type suitable for withstanding the climatic conditions with required Creepage distance as specified in bidding documents. The cable end terminals for terminating the cables shall be complete with accessories & fully compatible with the cables to be supplied. The terminations shall also be capable to withstand mechanical forces during normal and short circuit operations.

1.16.6 The cable end terminations envisaged for mounting on Transmission Line (T/L) Towers shall necessarily be of Composite Polymer type to reduce the weight on T/L towers. The cable end terminations envisaged for GIS interface**,** shall comply with IEC 60840**/62067**. It will be the responsibility of the contractor to ensure smooth interface with GIS equipment.

1.16.7 Rating/size selection justification to be submitted during detailed engineering for bonding cable and SVL.

2 CABLE DRUMS

2.1 Cables shall be supplied in returnable steel drums of heavy construction of suitable size and packed conforming to applicable standards.

2.2 Standard drum lengths **for each segment** for manufacturing shall be finalised during detailed engineering. Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow

and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

2.3 Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation, handling and storage. Both cable ends shall be sealed with PE/Rubber caps so as to eliminate ingress of water during transportation and erection.

3 TESTS ON CABLES

All **offered** XLPE insulated EHV cables shall conform to all Type, Routine and Acceptance tests listed in the relevant IEC & shall submit the type test reports for Employer's approval. If specified in Section-Project, Type tests shall be carried out on the EHV cable as per relevant standard.

4 TESTS ON ACCESSORIES

Contractor shall submit type test reports for accessories, as per IEC 60840/ IEC 62067 for Employer's acceptance. Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Section: GTR for Employer's acceptance.

5 TESTS AFTER INSTALLATION

All tests on cable system as prescribed in IEC 60840/IEC 62067 (as applicable) shall be performed after installation.

6 LAYING AND INSTALLATION

6.1 The bidder is advised to visit the site and acquaint themselves with the topography, infrastructure etc. The contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning of XLPE cables in all respects.

6.2 Cables shall be laid in the trench throughout the route. Further, as per requirement of the field, the cables shall also have to be laid in the followings (with prior approval of owner):

a. In ducts
b. In racks
c. In HDPE pipes (pipes to be filled with **fine** sand/ suitable **thermal backfill** material after cabling **as required**)
d. In air at terminations
e. At varying depths due to obstructions
f. As per approved drawings

6.3 At places where the cables cross private roads, gates of residential houses or buildings, the cables shall be laid in HDPE pipes of adequate strength.

6.4 Concrete trenches with precast covers may be used in exceptional cases in smaller portions, wherever bending of cables are involved and HDPE pipes can't be laid.

6.5 The arrangement of laying the cable en-route shall be submitted by contractor during detailed engineering for Employer's acceptance.

6.6 The installation, testing and commissioning work shall mainly consist of:

a) Detailed route survey for the entire route length under the scope of work.

b) Coordination for statutory Clearances from relevant authorities for laying of cables on behalf of Owner.

c) Laying of EHV XLPE cables & FO cables (if required) for entire route under scope as per specification. FO cables shall be laid in the same trench meant for Power cable.

d) After laying/installation of underground XLPE cables & FO cables, all facilities shall be made good. Part of cable laying may be through Railway Under bridges, Railway Crossing, Nallahs, Road Crossing, Army area Zone etc. Necessary road cutting and backfilling & compacting shall be in the scope of work. **However, top layer of Concrete/bitumen road (wherever required) is excluded from the contractor's scope.**

e) Formation of buried cable trenches for EHV cables as per specification including supply and installation of warning tape, providing layer of RCC Tiles as per drawing for entire route, construction of jointing bays, man holes, pull pits, backfilling of trenches & restoration as per specification. Buried trench will be measured in running meter (RM). Required main holes, pull pits, jointing bay are also considered part of buried trenches.

f) Underground Road & Rail crossings (as applicable) through HDPE pipe for cable and restoration as per specification through trenchless crossings.

g) Crossing of existing underground HT cables, gas pipelines and other facilitates on the route of cable through HDPE pipes.

h) Cable markers as per statutory requirements shall be provided all along the route at a maximum distance of 500 meters and other important locations. The location of underground cable shall be clearly indicated on the marker. **Joint markers shall be provided over joint bays.**

i) Supply and installation of straight through joints for complete route.

j) Supply and installation of all critical installation materials like trefoil clamps, neoprene cushions, support brackets etc. as required for complete route to avoid damages of the cable. Neoprene cushion shall be provided at road and rail crossings to avoid damage of cable due to vibrations during movement of trains and vehicles.

k) Bonding of screen/sheath to the earth station through disconnecting type link boxes and SVL (sheath voltage limiter). Bidder shall adopt cross bonding for

route under scope. Earthing stations /Earthing pits, earthing materials and earthing conductors wherever applicable for complete route including cable termination and earth link box at ends of cable shall be in contractors scope.

l) Providing, Construction & Erection of Steel bridge **as per BPS.**

6.7 Route Survey (for XLPE power cable & FO cables)

The bidder shall fully familiarize himself with the site and route conditions etc. The bidders are advised to visit the site and acquaint themselves with the topography, infrastructure etc. The contractor shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the erection and successful commissioning, of all cables in all respects. All materials required for the Civil and construction/installation work shall be supplied by the Contractor. The complete design and detailed engineering shall be done by the Contractor. The survey shall be conducted for underground routes to finalize the route and paths for the underground cables including location of straight through joints. .

The survey shall inter alia include the following minimum activities:

Map Study: The Contractor shall arrange topographical maps and other maps of the concerned area in proper scale. All links shall then carefully be studied using maps. Various feasible alternative routes shall be identified on the maps and the Contractor shall shortlist most suitable route and submit to owner for its approval.

Collection of details of other utilities: Contractor shall arrange information about existing underground facilities for the proposed routes. To do so as built drawing or route index diagram for various services viz water works, electric supply utilities, telecom services providers, public health, gas/oil authorities etc. may be collected from the authorities concerned. In case details are not available, the Contractor shall assess suitably by conducting enquiries and surveys and submit to owner for its approval.

Identification of cable route of underground power cables & FO Cables: The Contractor shall propose most suitable route for link keeping in view the following broad criteria:

a) The route shall be as straight and as short as possible.
b) Wet or unstable ground shall be avoided to the extent possible.
c) The route for the cables shall be away from the carriage-way of the road to the extent possible.
d) The route shall be suitable for placing manholes wherever required.
e) Future expansion of roads shall be taken into consideration to the extent possible.
f) Road, rail, river, culvert (nallah) crossing, trenchless digging shall be minimum.
g) As far as possible underground cable route shall be on the opposite side of the existing cables laid by DOT/BSNL or other utilities. Wherever both

routes fall on the same side of the road, a spacing of about 2.0 m is to be maintained, to the extent possible.

h) Care must be taken to avoid choosing routes, roads, areas that are prone to floods etc.

After finalizing the best alternative route, some trial pits shall be dug at suitably selected locations to assess the obstacles. It is necessary to locate the trial pits at proposed manhole locations. They shall be dug carefully keeping watch for the existing underground facilities. The presence of each type of facilities shall be recorded in the inspection note of the trial pit along with their sites sketch is kept in record for future reference. These details shall be enclosed along with the survey report.

The Contractor shall submit the survey report with the most suitable route for cable links along with details above. Contractor shall submit the final survey report for approval before implementation. The final survey report shall include atleast the following:

i. A drawing of the proposed route indicating all details of the route including relevant details of soil strata, bridges, culverts, causeways, rail over/under bridges, canal, defence area, underground gas/oil/water pipes line, power and communication cable routes, other important landmarks etc.
ii. The distance of the cable route from the canter of the road/rail/canal/river/bridge/culvert etc. shall be indicated on the route maps as well as documented in table.
iii. City/town/village/forest/defence etc. area coverage.
iv. Sections of the links where Trenchless Digging may be required.
v. Location and number of permanent and temporary manholes, Pull Pits, joint bays.
vi. Location of all turns, bends and major landmarks.
vii. List of authorities from which clearance shall be required to be obtained from each relevant section.

The final survey report shall have to be approved by the Employer and requisite clearances need to be obtained before the cable installation work is commenced.

The contractor shall prepare and submit for approval by the Employer, specific construction drawings for all types of soil strata/crossings taking into consideration the guidelines given in this specification. The construction/implementation shall be carried out as per the approved drawings.

The construction drawings shall inter-alia include the longitudinal sectional diagram of the trench for different soil strata and detail arrangement of crossings, number of pipes, size of pipes, location and position of manholes, other details as per the technical specifications.

6.8 **Statutory Clearances**:

The Contractor shall be responsible for necessary coordination with concerned authorities/agencies for obtaining necessary clearance for laying of cable and carrying out excavation/ digging work from the authorities on behalf of the Employer/owner and provide requisite copies of information, maps, survey report etc to the authorities. The Employer shall assist the Contractor in obtaining such clearances by providing the authority letter or any other relevant document. The Contractor shall make an all-out effort with the concerned authority to get clearances expeditiously. The Contractor shall ensure quick and speedy clearances in order to implement the project within stipulated schedule. In case the authorities have some objections on certain sections of routes proposed and are unwilling to provide clearances, the Contractor shall propose an alternate route, promptly carrying out the survey and submit specific survey report for that and reapply for clearance after taking into account the comments/objections of the authority. **However, statutory clearances charges shall be borne by the employer.**

6.9 Any other items not specifically mentioned in the specification but which are required for installation, testing, commissioning and satisfactory operation of the cable as per Indian standards/IE Rules/IE Act and concerned authority regulations are deemed to be included in the scope of the specification and no deviation in this regard shall be accepted.

6.10 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies, project management, loading, unloading, handling, moving to final destination for successful erection, testing & commissioning of the EHV cable and associated fiber Optic cables.

7 TRENCHING

7.1 The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.

7.2 The trench shall be excavated using manual /mechanical modes as per field conditions. Most main roads are of asphalt surface and some of the roads with cement concrete surface. The sides of the excavated trenches shall wherever required, be well shored up.

7.3 Where paved footpaths are encountered, the pavement slabs shall be properly stored and reinstated. Identification markers of other services shall be properly stored and restored. The excavated material shall be properly stored to avoid obstruction to public and traffic movement.

7.4 Suitable barriers should be erected between the cable trench and pedestrian/ motorway to prevent accidents. The barriers shall be painted with yellow and black or red and white coloured cross stripes. Warning and caution boards

should be consciously displayed. Red lights as warning signal should be placed along the trench during the nights.

7.5 The bottom of the excavated trench should be levelled flat and free from any object which would damage the cables. Any gradient encountered shall be gradual.

8 TREFOIL/FLAT FORMATION

Cables shall be laid in trefoil/flat formation (as per bidding documents) for entire route. The contractor shall submit drawings and arrangements for Employer approval.

9 CABLE HANDLING

The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surfaces, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in accordance with acceptable standard practices/statutory requirements.

10 DAMAGE TO PROPERTY

The contractor shall take all precautions while excavation of trench, trial pits etc., to protect the public and private properties and to avoid accidental damage. Any damage so caused shall be immediately repaired and brought to the notice of the concerned and to the Employer. The contractor shall bear all responsibilities and liabilities and shall bear all costs of the damages so caused by him or by his workman or agents.

11 CABLE ROUTE MARKERS/CABLE JOINT MARKERS

Permanent means of indicating the position of joints and cable route shall be fabricated supplied and erected as per approved drawings.

Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible and above ground surface.

The marker should incorporate the relevant information such that the name of the Owner, voltage, circuit and distance of cable from the marker.

12 DEPTH OF LAYING OF CABLES

Depth of laying shall be as per **Tender** drawing enclosed with Specification. Laying at varying depths due to obstructions/site conditions may be accepted in extreme cases with prior approval of Employer during detailed engineering.

13 PAYING OUT THE CABLE

The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out at uniform intervals. The paying out process must be smooth and steady without subjecting the cable to abnormal tension. The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion. The cables shall never be dropped. All snake bends shall be straightened. Suitable size cable stocking pulling eye shall be used for pulling the cable. While pulling the cable by winches or machines, the tension/ loading shall be monitored by tension indicator and shall not exceed the permissible value for the cable. The cable laying shall be performed continuously at a speed as recommended by manufacturer.

The cable end seals shall be checked after laying and if found damaged shall immediately be resealed. Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work. The integrity of the outer sheath shall be checked after the cable is laid in position.

14 SAND BEDDING

The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage (applicable where cables are not to be laid in pipes).

15 SNAKING

Snaking shall be done at necessary places recommended by manufacturer with prior approval of Employer.

16 THERMAL BACKFILL

If specifically mentioned in Section-Project/BPS, Thermal Backfilling shall be carried out based on the evaluation of soil thermal resistivity along the cable route and after approval from the Employer the contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables. Thermal back fill shall be of thermal resistivity of 1.20 K.m/W or better. **Test reports for the composition of desired thermal backfill shall be submitted to employer for approval.**

17 IMMEDIATE ENVELOPE TO CABLE

The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the Employer/Owner. The contractor shall seek prior approval on the use of the envelop material from the Employer/Owner before execution of the works.

18 BACK FILLING

Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock should be removed.

19 WARNING TAPE

A pre-warning, Red colour plastic/ PVC tape, of atleast 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route. The tape shall carry the legend printed in black continuously as under CAUTION; OWNER, VOLTAGE CLASS of CABLES.

20 PREVENTION OF DAMAGE DUE TO SHARP EDGES

After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench. Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be protected to avoid damage due to sharp edges. The cables shall never be bent, beyond the specified bending radius.

21 ROAD, RAIL & CANAL CROSSINGS

21.1 The road cutting, whether cement concrete asphalt or macadam road surface; Railway track crossing and canal crossing shall be taken after obtaining approval for cutting/crossing from the concerned authorities i.e. civic authorities, traffic police, telephone authorities, Railway authorities, Irrigation deptt etc., and work should be planned to be completed in the shortest possible time. Where necessary the work shall be planned during night or light traffic periods. HDPE pipes shall be used for crossing. HDPE pipes **inner** diameter should not be less than 1.5 times the cable diameter. **Class of HDPE pipes shall be proposed based on depth of HDD for employer.**

21.2 **Trenchless Digging**:

It is envisaged that trenchless digging shall be used for crossing the National highways, Railway tracks and Canals etc. and the same shall be in the scope of bidder. Trenchless digging shall also be used where the concerned authorities do not permit open cut method and it is essentially required to carry out for installation of underground cables. The trenchless digging methods shall generally conform to ITU-T L.38. The various methods of trenchless digging such as hand/ manual auguring (up to 15m), impact moling (from 16m to about 40-50m), HDD (above 40-50m) shall be adopted based on the soil/site conditions and the requirement. The exact method for trenchless digging shall be finalised during detail engineering as per actual site/soil condition. The equipment used for HDD shall be capable of drilling at least 100m at one go. The contractor shall propose the exact methods and procedures for implementation of trenchless digging at various crossings taking into consideration the following guidelines, for approval by the Employer:-

a) Excavation and backfilling of trial pits and verification of soil condition
b) Excavation of entry and Exit pits
c) Erection of drill machine for Drilling of pilot hole
d) Placement and driving hand augur
e) Placement and carrying out impact moling
f) Reaming and widening of bore holes in steps (if required)
g) Pulling of product pipe

22 FOOTPATH CUTTING

The slabs, kerbstones, on the roads shall be removed and reinstated without damage.

23 REINSTATEMENT

After the cables and pipes have been laid and before the trench is backfilled all joints and cable positions should be carefully plotted and preserved till such time the cable is energized and taken over by the Engineer in charge. The protective covers shall then be provided, the excavated soil riddled, sieved and replaced. It is advisable to leave a crown of earth not less than 50 mm and not more than 100 mm in the centre and tapering towards the sides of the trench.

The temporary reinstatement of roadways should be inspected at regular intervals, more frequently in rainy season and immediately after overnight rain for checking settlement and if required the temporary reinstatement should be done.

After the subsidence has ceased the trench may be permanently reinstated and the surface restored to the best possible condition.

24 MANHOLES

Manholes shall be provided at every proposed joint location for jointing bays. The bidder shall identify the location of the joint bays after carrying out detailed survey of the cable route and excavation of the trial pits. The delivery lengths of the cables shall match the location.

The Contractor shall get inspected, by a representative of the Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.

The contractor shall submit design and drawing of joint bay including manholes for withstanding a live load of 20 ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for testing the manhole for approval by the Employer. Manholes type approved by the Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries.

JOINTING BAY

(i) The bidder shall identify the location of the joint bays after carrying out detailed survey of the cable route and excavation of the trial pits. The delivery lengths of the cables shall match the location.

(ii) In case of underground portion, the joint bay should have a flat and level surface lined with bricks and properly plastered. The retaining walls on all sides, to the required height shall be of brick/ stone masonry. The top of the wall shall have a cement concrete bed 1:2:4 with 20mm size aggregate all-round. The top shall be covered with pre-fabricated RCC slabs and with an inspection cover. At the bottom in a corner, a sump pit shall be made for bailing out water.

(iii) The contractor shall submit design and drawing of joint bay for both underground and bridge portion for approval of employer. Drawings for earthing layout for the jointing bay shall also be submitted during detailed engineering.

25 TOOLS AND PLANTS

The successful bidder shall arrange, at his own cost, all necessary tools, plant and equipment to carry out the survey and cable installation work. The bidders are instructed to give all the details of equipment at their disposal, to carry out the work successfully and speedily.

26 BENDING RADIUS

The minimum bending radius of XLPE insulated cables shall be 20XD where “D” means the Outer diameter of the cable.

27 JOINTING AND TERMINATION OF CABLES

The cable jointing personnel and his crew shall have good experience in the type of joints and terminations that are used. The jointing work shall commence as soon as two or three lengths of cables have been laid. All care should be taken to protect the factory-plumbed caps/ seals on the cable ends, and the cable end shall be sealed whenever the end is exposed for tests.

Jointing of cables in carriage ways, drive ways under costly pavings, under concrete or asphalt surfaces and in proximity to telephone cables and water mains should be avoided whenever possible.

Sufficient over lap of cables shall be allowed for making the joints.

The joint bay should be of sufficient dimensions to allow the jointers to work with as much freedom of movement and comfort as possible. Sufficient space should be kept below the cable to be jointed.

The joints of different phases shall be staggered in the jointing bay.

27.1 SUMPHOLES

When jointing cables in water logged ground or under unforeseen rainy conditions, a sumphole should be made at one end of the joint bay, in such a position so that the accumulated water can be pumped or baled out by buckets, without causing interference to the jointing operation.

27.2 TENTS/COVERS

An enclosure or suitable protection cover shall be used in all circumstances wherever jointing work is carried out in the open, irrespective of the weather conditions. The joint shall be made in dust free, moisture free and clean atmosphere.

27.3 PRECAUTIONS BEFORE MAKING A JOINT

The cable end seals should not be opened until all necessary precautions have been taken to prevent circumstances arising out of rainy/ inclement weather conditions, which might become uncontrollable.

If the cable end seals or cable ends are found to have suffered damage the cables should not be jointed, without tests and rectification.

27.4 MEASUREMENT OF INSULATION RESISTANCE

Before jointing, the insulation resistance of both sections of cables shall be checked.

27.5 IDENTIFICATION

The identification of each phase shall be clearly and properly noted. The cables shall be jointed as per the approved design. Each cable shall have identification for phase at joint bays.

27.6 MAKING A JOINT

Comprehensive jointing instructions should be obtained from the manufacture of jointing kits and meticulously followed.

The materials used in the joints like ferrules, screen/sheath continuity bonds, lugs etc., shall be of good quality and conform to standards.

The jointing tools shall be appropriate and as per the requirement of jointing EHV XLPE cables.

28 CABLE LAYING & TERMINATIONS

The preparation of the cable end for installing the terminations and the precautions to be taken before fixing the terminations shall be followed as in the case of the cable jointing procedures. The instructions furnished by the termination manufacturer shall be strictly followed.

At cable terminating end, the following provisions for supply and erections are to be included:

(i) A sufficient length of spare cable shall be left in the ground, for future needs.
(ii) The rise of the cable immediately from the ground shall be enclosed in PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.
(iii) The cable shall be properly fastened using non-metallic clamps.
(iv) Appropriate labels shall be fixed identifying the phase circuit, voltage and date of commissioning etc., on the cable supporting structure.
(v) The sealing end shall be mounted on pedestal insulators to isolate them from their supporting steel work.
(vi) Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fibre shroud.
(vii) Providing earth stations with all required materials, like leads, connectors etc. Earth pits shall conform to IS–3043:1987 (Code of practice for earthing)/ or equivalent International standards.

29 BONDING OF SCREEN/ SHEATH

The screens/sheath shall be cross-bonded under each segment of specified route in accordance with IS-3043 (Code of practice for earthing) or applicable International codes & practices. The bidder shall offer complete cable system in order to limit maximum sheath voltage in accordance with relevant standards/ **code of practices** and furnish complete set of calculations in support of the same. The screen/sheath shall be connected to the earth stations/ earth pits through disconnecting type link boxes & through Sheath Voltage Limiter (SVL) as required.

All required materials used in the Cross bonding, termination of earth continuity cable, Link box, SVL etc to comply with specification/statutory requirements shall be in the scope of bidder and should be of good quality and compatible with the cable.

Regarding the Link box the specification should inter alia include the following features:

- **Should be Min. IP 65 weather protection**
- **Preferably the material should be of Stainless steel**
- **SVL of suitable rating shall be provided in Link Box wherever required**

Further details of Link box are enclosed in Annexure I.

30 CONNECTION OF RADIAL WATER BARRIER AND CABLE SCREEN

If the metallic radial water barrier is insulated from the metallic wire screen, a connection suitable to carry the currents occurring during operation must be installed between metallic radial water barrier of the cable and metallic wire screen in joints and sealing ends.

31 CABLE TERMINATING STRUCTURES

31.1 The terminating structure being supplied, should be designed as per the project requirement for the cable end terminations i.e. for Standalone Outdoor AIS terminations, GIS end terminations and Transmission line Tower end terminations as per requirement specified in BPS.

31.2 The mounting structure shall be fixed on the reinforced cement concrete foundation, the design & drawings of which shall be submitted to Employer for review & acceptance during detailed engineering.

31.3 The mounting structure includes the supports for cable end boxes, link boxes and any other item required for the intent of the contract. All steel sections used shall be free from all imperfections, mill scales, slag intrusions, laminations, fillings, rust etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Employer. The steel for mounting structure shall confirm to IS-2062 (latest).

31.4 In case of cable terminations on transmission line towers, the cable termination kit, LA, Link Box, SVL etc shall be fixed suitably on the tower for which necessary interface details shall be coordinated for Tower design during detailed engineering. After fixing the end terminations, the cable shall be suitably fixed to the tower members, with non-magnetic material clamps to the required height securely. The cable in air shall be suitably protected using HDPE pipes up to certain height.

31.5 In case of GIS end terminations, the structure & foundations shall be suitably designed in coordination with GIS terminations during detailed engineering.

32 MEASUREMENT (for Civil Works)

The buried cable trench shall be measured in the running meters including excavation, back filling, thermal back filling (if applicable), compaction, laying of concrete/ reinforcement, placing of warning tap markers, dewatering as required as per the drawing & specification & any other job required for successful completion of work.

33 Soil Data

The bidder shall be responsible for carrying out the required survey and should fully satisfy himself about the nature of soil expected to be encountered prior to the submission of bid.

The unit rate quoted by the Bidder shall be irrespective of soil type such as normal soil, soft rock, hard rock and crossings such as pavements, all types of roads, rivers, canals, nallah, culverts, rail track etc. encountered during the actual installation. The Bidders are required to make their own estimates and offer a single uniform rate applicable for all kinds of soil strata and crossings. The Employer shall not entertain any additional claims/payments for any type of soil/crossings encountered during installation. Employer strongly recommends site visits/investigation by the Bidders (at their own cost) before submission of the bid for proper estimations. The contractor shall be required to carry out excavation and back filling in accordance with these specifications and provide all additional items required at its own cost for proper installation not limited to those described in this specifications.

Unit rate for construction of buried cable trench and Backfilling shall inter alia include all related work/ activities such as excavation, blasting of rocks and backfilling of trenches, fixing of gradient of trench, excavation of trial pits if required, clearing of bushes, roots of trees along the trenches, cutting of bushes, trees, shoring, dewatering, excavation and backfilling of any temporary manhole, support of the existing facilities/plant, removal of let out material, breaking of pavement, clearing of obstacles, temporary reinstatement of footpath wherever required, providing all types of markers, warning RCC Tiles and tapes etc., suitable structure/techniques material for crossings(road, rail culvert, river, canal etc) for installation of HDPE pipe and other installation materials etc. The BOQ in the bid proposal sheets indicates the total route length to be implemented under subject package.

34 DISTRIBUTED TEMPERATURE MONITORING SYSTEM (DTS)

The bidder shall include and provide separate “Distributed Temperature Monitoring System (DTS)” for entire route for EHV cables complete in all respects along with terminal coupling equipment, workstation and all required hardware & software for real time monitoring of conductor temperature profile and to provide load predictions. The offered system should be able to provide maximum possible transmission capacity of the cable for each circuit. The distributed temperature monitoring system shall be optical fibre based, must be of proven technology and should be in operation for similar use along with EHV cables as per latest practices. The “terminal coupling equipment” and “workstation” shall preferably be microprocessor based with HMI, for displaying temperature along the length of the cable system. System shall provide potential free output contact for signalling to SCADA. The bidder shall provide brochures and catalogues for offered distributed temperature monitoring system along with the bid.

Optical fibre cables along with all jointing accessories etc required for DTS shall also be included in the scope of bidder. Optical fibre cables associated with DTS shall be laid in the same EHV cable trench **as per tender drawing enclosed with the specification/as per the recommendation of the DTS Supplier.**

34.1 Introduction

The Contractor shall provide distributed temperature sensing (DTS) systems in the stations, with measurement and communication with using optical fiber systems.

One purpose of the DTS systems is to provide a thermal condition monitoring system to detect hazardous changes in the cables thermal environment. Another purpose is to provide near real-time fault location capabilities, since the DTS system shall also serve as an OTDR system to quickly locate fiber breaks.

Cable temperature monitoring shall be based on DTS systems that use optical fiber technology and laser light. The DTS optoelectronics and display equipment shall be rack mounted in each station's control room.

The Fiber Optic Cable for DTS System shall be designed for installation in HDPE conduit, with water blocking capabilities and suitable for installation in environments with electrical interference with HDPE sheath. The temperature profile along EHV XLPE Power Cables shall be measured and monitored by DTS equipment by using Multimode cores. The DTS system shall be fully redundant including the multimode fiber (within the same cable) connecting both end Substations. The DTS systems (including redundant system) shall be kept preferably at one Substation and the other substation shall have HMI with full information as available at local DTS HMI. For communication between the two Substations dedicated telecommunication link between the two terminals (with FOTE interface at transition station) may be used.

34.2 Main characteristics of the DTS systems

The Contractor shall specify in detail:

i. Calibration methods for the DTS system
ii. Methods to synchronization current input and temperature measurements

For both fiber types:

i. Fiber-interruption detection
ii. System fault detection (auto check)
iii. Watchdog (alarm true hardware relay)
iv. Automatic restart after power interruption
v. Operating temperature : 0– 50°C
vi. Power supply: 110V/220 V dc or 230-240Vac-50Hz
vii. Cooling equipment if needed (maximum ambient temperature: 50°C)
viii. Cubicles or rack mounts for DTS systems; All equipment will be mounted in these cubicles

The contractor shall furnish GTP of DTS for approval during detailed engineering as per format enclosed in Annexure II.

34.3 Electromagnetic compatibility (EMC) of the DTS systems

All DTS equipment shall be designed for electromagnetic compatibility within electrical power substations in accordance with the European EMC guideline. Furthermore the equipment shall be compliant with:

i. Minimal compliant to EN 61000-6-2
ii. Preferentially compliant to IEC 61000-6-5

34.4 DTS system documentation

The Contractor shall provide a distributed temperature sensing (DTS) system report, describing the proposed system to be provided, including:

i. Technical documentation stating DTS system power supply requirements, accuracy in temperature, spatial resolution, maximum allowable fibre attenuation at operating frequencies, measuring intervals, for various fibre ranges, etc.
ii. Descriptions and interface requirements with the converter station SCADA systems
iii. Descriptions of output protocols to SCADA for eventual display of real-time temperature profile and zone alarm data to remote converter operators and Transmission System Operators
iv. Descriptions of methods to be used by remote specialists to modify DTS system settings, oversee functionality and retrieve historical data.
v. In addition, detailed documentation of the DTS system shall be delivered as listed below. All Standard documentation may be in English including the following:
vi. Schematic overview of the system
vii. Test reports
viii. Material list
ix. Electrical drawings
x. Lay-out drawings
xi. User manuals DTS
xii. User manual converter system
xiii. System warnings
xiv. Maintenance prescriptions and schedule

34.5 DTS system training

The Contractor shall provide training of the DTS systems for following users:

- User group – central control room (dispatch). The following topics must be treated (not limitative):
  (i) Basic principles of DTS measuring system
  (ii) General layout of the DTS system
  (iii) Possibilities and limitations of the DTS system
  (iv) Input and output of the system
  (v) Interfaces for this user group
  (vi) All Training must be provided in English.

- User group – Engineers. The following topics will be treated (not limitative):
  (i) Principles of DTS measurement in detail
  (ii) Layout of the DTS system
  (iii) Possibilities and limitations of the DTS system

(iv) Input and output of the system
(v) Presentation of all accessible interfaces of the system
(vi) Detailed information regarding DTS software
(vii) Calibration of the system
(viii) Remote access to the system
(ix) Use of the mobile access to the DTS system
(x) All trainings must be given in English

The Contractor shall propose draft content of both training sessions to the Employer. All modifications at Employer's request shall be included.

35 OPTICAL FIBRE CABLE (For Communication Equipments)

If specified in the bidding documents, Optical fibre cable required for Communication Equipments shall also be laid in the same cable trench in separate HDPE pipe.

Annexure I

1. Link Box

The Bidder should include Three Phase & Single Phase Link Boxes for (i) Bonding of the Cable earths, (ii) Provide sealed, waterproof enclosure for Bonding cable earths (iii) to allow testing of shield breaks and cable connections as per the requirement. Link Box should be of water proof environment for sheath bonding connections that make it to maximize cable load ratings by minimizing sheath current flow. It should be provided with ground connection inside Link Box for each section of sheath circuit. Link Boxes are to be installed at locations where sheath continuity is interrupted. Links inside link Box should be removable allowing sheath connections to be easily isolated for electrical testing. Link boxes should have the following features

- Accommodates Single Core Cable & Concentric cables
- Suitable for earth Cable leads
- Different designs available : Single point, cross bonding, direct grounding versions
- With or Without SVL, Zinc oxide sheath voltage limiters can be used.
- If required, Heat shrink tube with adhesive for water proof sealing at cable entry.

2. Standards Applicable

The latest revision of the following IEC/AS standards shall apply:

IEC 60099-4	Sheath Voltage Limiter
IEC 60529	Ingress Protection
IS 3400 P-22 -1984 Ra-2008	Neoprene Rubber
IS 1367 (Part 14) 1984 (Reaff.2001)	SS 304
ASTM B152/B152M	Copper Sheet

3. Technical data

The following design parameters are required for Link Box as per the Voltage Class rating**:**

Rated voltage	kV	
Rated power frequency withstand voltage	kV	
Rated lightning impulse withstand voltage	kV	
Rated frequency Insulation Resistance Contact Resistance Degree of Protection 1. For structure mounted 2. For Buried	Hz Ω Ω	

The following design parameters are required for Sheath Voltage Limiter

Rated voltage	kV	
Maximum Continuous Operating Voltage (MCOV)	kV	
Insulation withstand of housing 1) 1 minute Power frequency Voltage	kV	
2) Standard lightning impulse Voltage (1.2/50 micro sec)		

4. Tests

All tests shall be carried out according to relevant IEC/AS standards.

Type tests: The Link Box is to be type tested at a recognized and well-reputed test laboratory. The Following tests apply include

- IP 65 test
- IP 68 test
- Impulse test
- Contact resistance test.
- Short Circuit Current test (SCC).

Type test certificates shall be available for verification as evidence of successful completion of type tests.

Routine tests: Tests to be carried out according to IEC/AS Standard requirements. The following tests apply include

- Visual & dimensional inspection
- Insulation Resistance Test
- 25 kV High Pot Test
- SS 304 Detecting Test

Annexure II

GTP for DTS: To be furnished during detailed Engineering

Sr No	Requirement	
A	**DTS**	
1	Measurement specification	
	Mode	
	No of Channels	
	Temperature Resolution	
	Sampling Resolution	
	Range	
	Working Principle	
	Attenuation	
	Optic Fibre Cable	
2	Operating system	
	Internal Hard disk	
	Operating System	
	RAM	
3	Environmental specification	
	Power Supply	
	Operating Temperature Range	
	Humidity	
4	Supplied software	
B	**RTTR Server / Dynamic Cable Rating Server (DCR Server)**	
1	Operating System	
2	Interface	

C	Real Time Thermal Rating Software (RTTR)	Dynamic Rating Software (RTTR)
1	Integrated Power Cable Dynamic Rating Software (RTTR)	
2	Software based on IEC standards.	
3	Viewing Software with RTTR.	
4	Data Transfer	
5	Indoor Cabinet	
6	UPS Details	
7	Accessories	