

EHV Cable Laying Manual

INTRODUCTION

The purpose of this method statement is to provide the contractors with safe working practises for laying of Extra High Voltage power cables outside the substation in open trenches. Laying the power cables inside of substations will be subject of separate method statements for each substation. The brief scope of work is as follows:

The civil works (Cable trench excavation, Joint Bay construction as per approved drawing) executed by Cable laying contractor EHV Cable 66/110/132/220KV

The following methods for laying the cables may be used:

- Nose/End pulling
- Continuous bond pulling
- Driven rollers
- Caterpillar machines – pushers
- Manually assistance
- Combination of two or more above mentioned.

As the installation of every cable section differs in detail, it is not possible to lay down other than general instructions. The possible causes of damage during installation are due to: -

- Excessive and pulling tensions
- Excessive bending
- Accidental damage to the cable serving and/or metallic sheath.

REFERENCE DOCUMENTS

1) Quality Assurance Plan, 2) Work Order of sub-contractor with complete scope.

SAFETY DOCUMENTATION

- Permits to work from concern department and authority
- Clients Approved route and civil Work drawing

LIMITS OF WORK

- All works will be limited to those contained on any safety document issued and to the contents of this Method Statement. Any works outside the remits of this Method Statement will require the approval of further documentation by client. The working area will be demarked as per approved cable route drawings.

METHOD OF WORKING

- Prior to commencement of cable laying works, check for the following documents to be available on site with each site engineers:
- Valid Permits from the following authorities.
- Land Department /Local Authority /Municipality/PWD/NHAI/Railway etc as applicable
- Client (end User/Owner)
- Traffic department (If Required)
- Availability of all Approved cable route /Laying drawing.

Power Cable Installation

Permissible parameter of cable pulling

Maximum permissible pulling tension (Conductor/Pulling eye cable pulling)

- Prior to actual cable pulling, pulling tension is calculated and final pulling tension is certified less than the maximum permissible pulling tension.
- Maximum permissible pulling tension of cable is calculated by the following formula;
- $T_{max.} = [\text{Conductor area (mm}^2\text{)}] \times 7\text{kg/mm}^2 = \dots\dots\dots\text{kg}$

Maximum permissible cable sidewall pressure

- Sidewall pressure for cables of bending part shall be applied less than 300kg/m generally as defined by the following formula,
- $P = T/R[\text{kg/m}]$ Where, T: pulling tension at exit from bend [kg] P: sidewall pressure [kg], R: bending radius [m]

Minimum bending radius

- Normally bending radius for single core cables shall be applied more than "20 x D" during cable laying. Specified bending radius for the cable is as follows;
- **Calculation of cable pulling tension**
- Typical coefficient of friction
- Roller method (direct burial) : 0.1 ~ 0.2
- PVC/PE pipe with lubricant method : 0.15 ~ 0.3
- PVC/PE pipe without lubricant method : 0.3 ~ 0.5

Pulling direction

- Pulling direction should be decided so that the pulling tension and sidewall pressure are below the maximum allowable value during the cable pulling. One of the ends of the cable route is selected for setting of cable drum and other is for the winch according to the basic design of cable pulling. At this time the space for setting of cable drum should be considered.

Drum Delivery

- The cable drums shall be delivered to site from main store either by a purpose-built drum-trailer, or by low bed trailer and then unloaded with a crane on to the drum stand or nearby cable pulling ramp in plane and rigid surface.
- The crane shall be fit for purpose and shall have adequate capacity to lift the drum and install in the final position for installation.
- Lifting shall be via the approved lifting points on the drum and with slings of good condition. All equipment that is not in suitable condition shall be removed from site immediately.

TYPE OF PULLING:

Nose/End Pulling

- The steady maximum permissible pulling tension shall not to exceed as per calculation/GTP for the cable conductor cross section used on this contract. The permissible side wall pressure for lead sheathed copper conductor cables is not to exceed 500Kg/m. If the calculation of pulling tension and/or side wall pressure exceeds permissible values, and, where the use of manual labour is impractical, then the continuous bond or an equivalent aided method must be adopted.

- If the route includes several right-angle bends (or equivalent), the pulling tension and side wall pressure created by a nose pull, would certainly exceed these values. Therefore for these conditions a cable pusher could be used to reduce the tension and maintain the pulling tension within the limit, alternatively a bond pull may be used.
- The connection between the cable pulling eye and the wire bond, (ideally none stretching) must be made by means of a ball bearing or equally efficient swivel to permit tension to be taken, and not transferred from the wire bond, without imparting a twist to the cable, if a power winch is used a dynamometer or equivalent measuring and/or controlling device must be used.
- If the bends on the cable run are predominately located at one end of the trench, it is generally preferable to locate the drum at that end, if site conditions permit.
- In most of cases the preferred method will be to use a Cable Winch and Cable Pushers (where and if necessary).
- Generally, cable pulling by winch is common and mostly used for this type of Power Cables due to the simplicity and types of route/section lengths anticipated for this contract. The process and content will be the same for any given section. The only major consideration while pulling the power cable is to keep the pulling tension lower than the allowable pulling tension. The cable winch that is going to be used for this project is fitted with a tension limiting device, which will be used to pre-select the maximum pulling force, this will ensure that the **maximum tension on the cable will not be exceeded**.
- Should self-driven rollers need to be used, they will reduce the friction and back tension, a cable winch will be necessary to guide and pull the cable from roller to roller. The winch will take the cable through each roller position and will prevent slippage and ensure constant movement which will prevent any sheath damage. Care must be taken with the powered rollers to ensure that in case of the cable stopping then the rollers must also stop immediately with synchronise way.
- Most of the cable installation that is carried out in India is carried out by **Nose/End Pulling** method, and the operatives are more comfortable and familiar with it. Both Sterlite Power and their subcontractors are more experienced with this method of installation and have installed numerous of EHV Cable Lines.

Continuous Bond

- With this procedure the pulling force is taken by a wire bond to which the cable is tied at regular intervals and the cable is virtually carried through the route with the wire bond taking the strain. The trailer mounted re-wind storage drum for wire bond is positioned at the drum end of the trench. Skid plate and roller assemblies are positioned on the inner side of all bends in the trench and snatch blocks mounted on the opposite side of the trench with 100 mm x 50mm channel anchor blocks.
- The cable is fed into the trench by hand for a distance of 9m to 12m and then tied with untarred marlin or nylon card to the wire hawser at intervals of approx, 2m. The pull is commenced and successive ties are then applied, with the cable in motion. On the cable arriving at a point approx. 2.7m from a bend where a snatch block is fitted, the ties are removed and the cable guided round the bend or duct block, the cable is then re-tied to the bond. This is a continuous process and carried out with the cable in motion. This process is repeated until the cable reaches its final position.

- **This method of** installation is preferred where a conventional nose pulling is not possible due to the number of obstructions or excessive number of bends within the cable section.
- **On completion** of pulling one cable the wire bond may be re- wound, or alternatively two or three cables may be laid and the wire bond re-wound in one operation. This is usually carried out within the natural meal/rest breaks between the cable pulls.

List of Equipment Required for Cable Pulling Work

- Motor driven winch (5 to 10 ton capacity with load controller/load reader/recording facility)
- Cable ramp roller, Corner roller frame assembly, angular roller, triple cable roller, cable pulley,
- Cable Pulling Socks, swivel
- Metal fairleads (cable rollers).
- Hydraulic jack and drum trestle, shaft.
- A type ladder (for Height work), Pulling Tirfor equipment.
- Hard barricades,
- De-watering Pump & Pipe, Portable generator, power cutter, tool box, wooden batten/blocks, Robber sheet, MS pipe, tent materials. Scaffolding materials.
- 45-50mm MS pipe and scaffolding clamp (qty. as per site condition/requirement)
- **Manually Assisted Method**
- Conditions a rise in practice where mechanical aid means are limited or cannot be used. In such cases cables are laid satisfactorily with **manual labour** distributed along the lengths of the run. This method may also be used as an alternative, providing enough site labour is available. Care must be taken in ensuring that enough staff are available and that the efforts are co-ordinated.

Procedure of cable pulling

Inspection of cable route condition:

- Before the cable pulling work commences, the whole trench/ pit/ tunnel is to be inspected jointly by client & Contractor, and they must have been notified at least 24 hrs before.
- In case of the direct burial type trench, the thermal bedding for the cables should be installed smoothly and **any objects** as the gravel, which has fallen from the ground to the surface of bedding sand should be removed.
- Checking installation of the pipe ducts and cleaning them properly.
- Before the cable pulling work commences, the pipe ducts for road crossing, etc. are to be checked to ensure that they are correctly aligned and to be cleaned.
- The cleaning brush having suitable size for pipe ducts should be passed through the pipe ducts and removed any obstacles in the pipe
- Setting cable pulling winch and drum of cable pulling wire
- The cable pulling winch is to be fixed firmly so that it can stand against the pulling force. The anchoring and plug supporting will be considered in each place separately and will depend to the local conditions and pulling forces expected. All manufacturers' recommendations and provisions will be respected, followed and used. Kinks in the wire rope will not be allowed and must any bond must be removed from site.

- The winch is to be capable of changeable pulling speed in the range of 0~ 30 meters per minute.
- The winch shall be equipped with a tension limiter and meter in order to control the cable pulling tension. The winch will be fitted with overload cut-out and chart recorders. Chart records will be used to record the pulling tension.
- The bond drum shall be set at the appropriate position in order to roll up the wire bond easily.

Inspection of the cable surface

- Outer surface of the cable is to be inspected visually continually monitored throughout.
- Setting cable rollers / curve rollers
- Cable rollers are to be placed at suitable positions into the trench/pit/tunnel.
- The intervals of the rollers are to be kept approx. 2 meters in straight sections so that cable should not touch ground or side wall.
- In case, if there is any slope vertically or horizontally of the trench, intervals of the roller are to be kept approx. 1 meter.

The rollers shall be maintained to rotate smoothly. If the cable is planned to be pulled through the corner, the correct type of rollers should be positioned correctly to ensure easy installation with no damage to the cable. Rollers should not have any sharp edge which may cause damage of cable if rollers did not place properly.

- The bell mouths with guide rollers shall be installed at ducts in the road crossings or other service crossings.
- The key rollers will be secured by bracings supported to the trench walls.
- Setting guide rollers with supporting facilities (Sand Bag may used)
- The cable guide rollers are positioned at the appropriate locations between cable drum and trench / pit / tunnel in order to be guiding the cable from cable drum to the trench/pit/tunnel smoothly.
- Setting portable telephone/mobile/communication to team along the cable route
- After the equipment has been properly placed, the portable telephones are to be located on the drum side, leading end of the cable and the winch side. They are utilized to control the cable pulling speed and other communication.

Laying of wire bond in cable route.

- The wire bond should have four times as much safety factor as the calculated maximum value of pulling tension for the pull.
- It is important that the wire is to be handled in such a manner that it is not twisted, or kinked

Connection of the wire bond to the cable

- The factory fitted pulling eye that is fixed on the nose of the cable is connected to the bond wire by a swivel and shackles. A swivel and shackles should have the proper size for cable pulling and be in good condition, with the swivel freely rotating.

Cable Pushers

- In the sections having a number of bends, and where the cable pulling tension has been calculated as high, hydraulically operated independent cable pushers equipped with soft Vulcan-rollers shall be positioned at some of the bends. These cable pushers will give the necessary relief on the cable by removing some of the back tension on

the cable, but they will not damage the sheath in the event of the cable stalling and stopping. By pulling and pushing the cable at the same time there will be a very low level of tension on the cable. The calculation of pulling tension will determine the positions and number of the pushers, and pushing forces required.

Cable pulling

- Each pulling section will have a drawing/sketch clearly showing the positions of winch and drum and calculated pulling forces. The back tension will be controlled by either a motorized friction brake or a simple wooden brake and kept as low as possible without the coils on the drum becoming loose/touch ground.
- Cable pulling is to be started gradually. A watchman is to be located at nose of the cable, will walk along with the nose of the cable as it is being pulled.
- Positioning of pulling staff shall typically be; 2 persons to travel with cable end, drum operator and 3 persons at drum point, labours at every 20mtrs or every trench bending and sections to guide the cable along the cable route, winch operator with 2 labours at winch with conference communication each other in between the route.
- Tension the wire bond and reset the straight rollers position accordingly. Set the maximum tension on computerised recorder for automatic tripping of the winch on overload.
- **"Whistle to alert"** and start pulling. Keep the cable speed and tension in view of the under constant review and do not let it exceed the maximum value.
- Should any problems arise, the pull will be stopped immediately and not re-started until the problem has been cleared.
- Care must be taken when the cable approaches the terminating point (jointing position) at the winch side and tail end of the cable is just going off the drum. The pulling speed must be carefully regulated.
- If the cable remains on the drum when the top of the cable of reached the termination point at winch side, the pulling must be continued to make a stage where the tail end of cable is just going off the drum.
- After finishing of cable layng, take out the printer record sheet of pulling from the electronic recorder and preserve.
- Laid cable should be covered by sand bag to avoid any external damage outer sheath by falling any materials on cable, extra cable should be protected with proper care and both end sealing should be checked, if required additional sealing to be used.

Cable pulling in pipe duct

- When the cable is to be installed into a duct, the pipe duct should be checked to ensure that it is suitable for cable pulling as inner diameter, bending radius, etc. All ducts will have a mandrel passed through them prior to installation.
- Special equipment may be necessary which are different from the equipment of cable pulling for open trench may be required to ensure that the cable is installed correctly.
- Guide facilities are rollers, supports, etc. which are installed between cable drum and the pipe duct entrance into manhole on the cable drum side.
- Bell mouths with guide rollers, supports, snatch block, etc. which are installed in the duct mouth.
- Cable pulling lubricant/grease is applied around cable to reduce the friction between the cable and the ducts, this is more applicable where the ducts pipes have a change in direction, elevation or that they are of excessive length.
- Brush off remaining lubricant from cable surface on exit side of the duct.

- Any damage occurring during the installation will be informed to site in charge / cable laying supervisor immediately. No damaged areas shall be installed into ducts until on inspection has been carried out. Any serious sheath damage shall be identified with coloured tape and its location monitored to ensure that it does not land in a duct **without being repaired**.

If necessary, rags can be tied around the cable during installation to remove any small particles that are there.

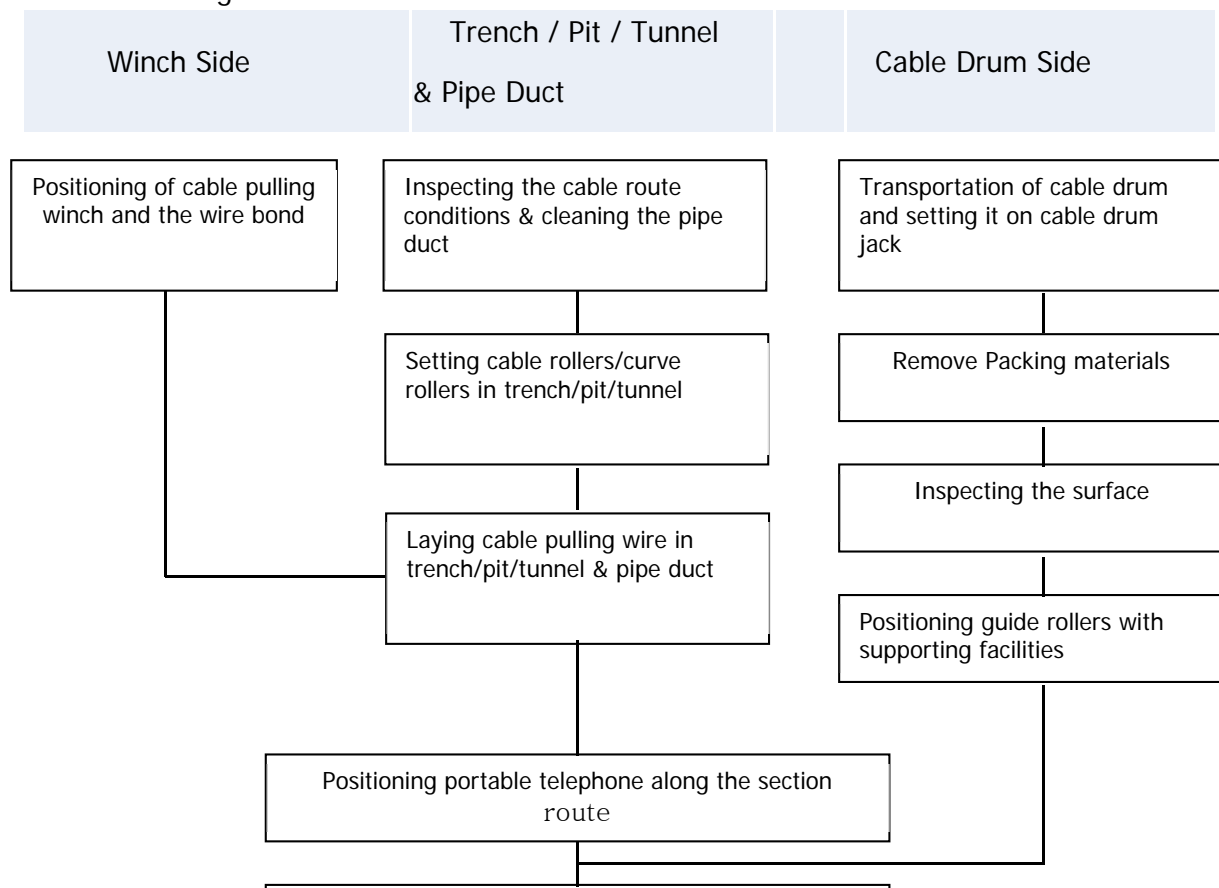
Cable pulling in Cable Tray in height:

Cable Laying in trestle with full safety and extra precaution to be taken such as height work, Cable laying in raiser portion will be done through rope and pulley so that cable can pulled up way direction in controlled way, skilled worker should work with complete PPE.

- Rollers must be fixed in cable tray / support arrangement in trestle area.
- During cable laying work, Cable "I" always should be fixed with rope and solid support as it will not slip from rollers.
- Sufficient skilled manpower to be deployed with PPE at trestle area for cable pulling work. Proper illumination and walkway should be hazard free, hand rail must be
- Life line rope must be fixed in walk way along the cable route, safety belt must be tightening while working and cable laying work.
- If possible, cable pulling may done with the help of pulley and rope in guidance of cable rollers, adequate precaution must be taken for not to touch cable in any side surface of tray, sharp edge, supports, corners, these may damage outer sheath and lead to fail sheath integrity test.
- Ladder plan fixed typed or "A" type portable ladder may use for approaching cable trestle and cable laying route, there should not be any shortcut.

Cable Pulling Work - A flow chart

- Cable laying in trench / pit / tunnel (By Pulling Eye)
- Typical procedure for the cable laying work in trench/pit/tunnel is shown by the following scheme.



- **Cable Arrangement**

- After cable pulling all equipment will be removed and put out of the trench. Care is to be taken to avoid cable damage and labourers must not step on the cables. Cables must not be left on the installation rollers for any extended period and not left on the rollers overnight.
- Road Crossing or wherever ducts/HDPE pipe used will be sealed properly.
- Excess slack from the cables will be organized according to snaking method at both sides of the joint bay. Phase's transposition is to be done, Transposition is always located in accordance with the cross-bonding diagram
- The phase marking, after installation will be by Colour tapes (red, yellow and blue) should be wrapped around the cables for phasing, in accordance to the cross-bonding diagram.
- Cables will be then arranged in the joint bay and protected by sandbags. If required extra cable lengths may be cut and ends protected/sealed using shrinkable caps to prevent ingress of moisture.

- **Inspection and Repair of the outer sheath**

- The Contractor operator in the presence of the Engineer must carry out this test unless otherwise agreed. An Inspection Report will be used to record the test results.
- In case of any sheath fault damage to be reported to Cable laying Engineer/Sterlite Power by an appropriate method with photographs for review and approval before commencement of sheath repairs.

- **Test Requirement**

- The cable sheath shall withstand a voltage of 10KV applied between the earth and the metallic sheath for one minute. This shall be carried out on each length of cable after laying, dune sand surround and filling, installation of concrete tiles and pipes bentonite (where applicable). Test will be recorded on Site as per standard format.

- **Test Procedure**

- This testing voltage will be applied between the metallic sheath and the earth. One person must be posted at the end of the cable to warn workers in the area of the potential danger. No one shall work in the during the testing with same cable section.
- After testing the metallic sheath will be earthed / discharge and sealed properly

- **Backfilling**

- Before the backfill is placed the power cables will be inspected to confirm the spacing/dressing, no foreign materials should around the Cable except sand

- **Route Marker**

- Approved Route Markers shall be required at both ends of joint bays, locations where route changes direction, at both ends of ducts road crossing and at a maximum interval of 500m on straight runs or as instruction by Engineer in charge.
- **Clearance of Site**
- Site clearance on completion of the works and removal of material shall be to an approved position for disposal
- **EMERGENCY PROCEDURES**
- Any incidents, accidents or near misses will be recorded as per our own H&S systems and the Client will be notified immediately so that they can complete their own procedures.
- Details of the nearest Accident & Emergency department will always be given to each operative at the site induction and be available within the site staff.
- Inform emergency department of the concerned service department immediately in case of any damage to the existing services. The emergency services (nearest) contact nos. are as follows:
 - Hospital / Drainage Dept. / Telecom Dept. / Building Engineering Dept. / Land Dept. / Client / Police/Fire etc.
- **PERSONNEL PROTECTIVE EQUIPMENT (PPE)**
 - Safety Manual
 - Hard Hat
 - Safety Boots
 - Hi Vis Clothing for night
 - Gloves

Ear Protection / Eye Protection (where required)

PLANT AND EQUIPMENT REQUIRED AT SITE FOR CABLE LAYING WORK

- Cable pulling winch with chart recorder and overload cut-out
- Hydraulic cable pushers
- Hydraulic jack / Cable drum trailer
- Flat rollers / Corner rollers / Curve rollers
- Stand rollers of various height (Draw off rollers) / V – rollers (Guide roller)
- Cable pushers (Hydraulic)
- Bell mouths
- Fibre blowing equipment / compressor
- Swivel links / Slings
- Mandrel / Duct brush
- Water Pumps, if required

RESOURCES AVAILABILITY FOR EHV CABLE LAYING PROJECT

- Project Engineer / Site Engineer
- QA/QC Engineer & Safety Officer
- Foreman (1 No.)
- Labourers as per site condition
- Winch operator & Drum Operator
- Crane Operator & Heavy truck driver
- **PROTECTION MEASURES**
- All personnel entering the working area must understand the contents of this Method statement be signed on to it.

- All temporary signs shall be mounted on bases, which are designed to accept sand bags or a similar approved device which creates a stable base.
- Traffic safety cones with safety tapes tied across each cone shall be kept throughout each cable trench section and suitable barricades shall be erected wherever required in order to prevent any accident.
- **WASTE MANAGEMENT**
- Demobilize the equipment's and machinery from the site and surplus waste materials and any other litter if any shall be taken away from the site.
- **HOLD POINTS**
- Notify for inspection 24hrs in advance before laying of cable outside the substation.

Cable Ramp Rollers



Cable Laying and Protecting with Sand Bags after laying completion, one by one all cables, every time.



Cable Laying Dressing, Phase Marking, Sand Filling



Backfilling with Sand, RCC Slab, Soil and with Warning Tape and complete by soil



Laid cable protected by sand bag against any external damage of outer sheath



- **Points to be noted for EHV Cable Laying:**
- After Joints Bay Construction Cable laying work may be started.
- Contractor must have experience for EHV cable laying work and skilled workers.
- Contractor must have plant & machinery required for EHV cable execution projects.
- Excavation may be done as straight as possible in view of cable laying with minimum tension.

- Enough sand bags must be available at site for covering of laid cables, laid cable should not be exposed in any location, outside the trench or in JB, Cable always should be above sand bed and cover with sand bag always. Cable roller always supported by sand bag wherever required.
- Cable Ramp always to be prepared at drum side with proper angle so that cable may laid smoothly from drum to trench. Proper good working rollers only used for cable laying work.
- Barricades must be used during excavation and cable laying work.
- During Cable laying smooth speed should be maintain and pulling tension should not be more than calculated tension.
- Always we should take care for water and moisture ingrain in cable, required precaution must be taken cares and if any cut found in end cap of pulling I, must be replaced with new end cap.
- During cable pulling, cable should not touch any hard/sharp surface, which may cause of sheath fault.
- End cap must be provided in HDPE pipe, before cable pulling all HDPE pipes must be cleaned with proper ways so that no foreign materials left out inside HDPE pipe, which may cause damage of EHV cable or its sheath.
- Safety stewards must be available at site, First aid box should available all time at site.

