Industrial Engineering Letters
ISSN 2224-6096 (Paper) ISSN 2225-0581 (online)
Vol.4, No.8, 2014

Installation, Testing and Jointing of LT and HT Power Cables up to 33 KV

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Abstract
In the electrical power distribution and transmission system for urban and rural area, overhead lines are usually in major practice. Underground system was not favourable in developing and under developed countries. The main reason behind it was the much higher capital investment of underground cabling with respect to overhead bare conductors. But with the advancement in technology and market competition its cost is manageable for urban areas. This system requires more skills and planning for installation, jointing and termination rather than overhead lines. The presented paper is applied on power distribution system up to 33 KV.
Keywords: LT/HT power cables, Installation, Jointing, Termination, Testing.

1. Introduction

The fist step for the cabling system is selection of cable sizes. Voltage drop is the considerable factor for the selection of LT cables but in case of HT cable selection depend on short circuit current and current carrying capacity. After selection of cable there will be an inspection visit at manufacturing unit before dispatch. There will be numerous testing on cables to ensues the acceptibity as per electrical standards and site requirements. Essential testes are listed as below:-

- Tensile test (for Aluminium conductor)
- Wrapping test (for aluminium conductor)
- Annealing test (for copper conductor)
- Thickness of insulation and sheath
- High voltage testing
- Insulation resistance test
- Hot set test (for XLPE cables only)

2. Cable installation

After satisfactory testing the cable drums will be dispatched to site for installation work. Installation work will follow a sequence of activities. The major points to be explained as under :

1. Storage of cable drums
2. Route survey for installation
3. Type of installation
4. Road crossings/pipe laying
5. Trenching
6. Cable laying in (trench/trays/ducts/racks)
7. Testing at site
8. Jointing
9. Route markers

2.1 Storage of cable drums

Cable drums always shall be placed/store on dry and hard surface. Paved area is best for storing. There shall not be any kind of water logging. Drum shall always be kept on its flanged instead of flat surface. Whenever the storage time is very long then rotate the drum at 90 degree after every 3 months. The direction of drum rotation should match the direction of arrow marked on the flat side. There is no need to cover the cable drums but try to keep away for hard sunlight. Both the ends of cable should be sealed by insulation cap to avoid moisture ingress.

Storage of cable drum

2.2 Route survey

Before starting the other activities there should be a detailed survey of route. Route shall be so selected that trenching work for cable shall not jeopardize existing utilities, which are vulnerable to damage. Maintenance point of view is also important. It should be straight along the roads/footpaths with some space for offset. Trench shall always be kept away from drains and property lines (specially for LT cables). HT cable shall be closer to the kerb line instead of LT cables. Different trenches shall be used for different voltage levels. If extra space is not available then kept the lower voltage cable above the higher voltages. Gap between power and communication cable shall be minimum 600 mm horizontally as well as vertically.

2.3 Type of installation

- Laying in closed pipes/ducts
- On trays
- On surface by clamping
- Underground
- Entering in building

2.4 Road crossings/pipe laying

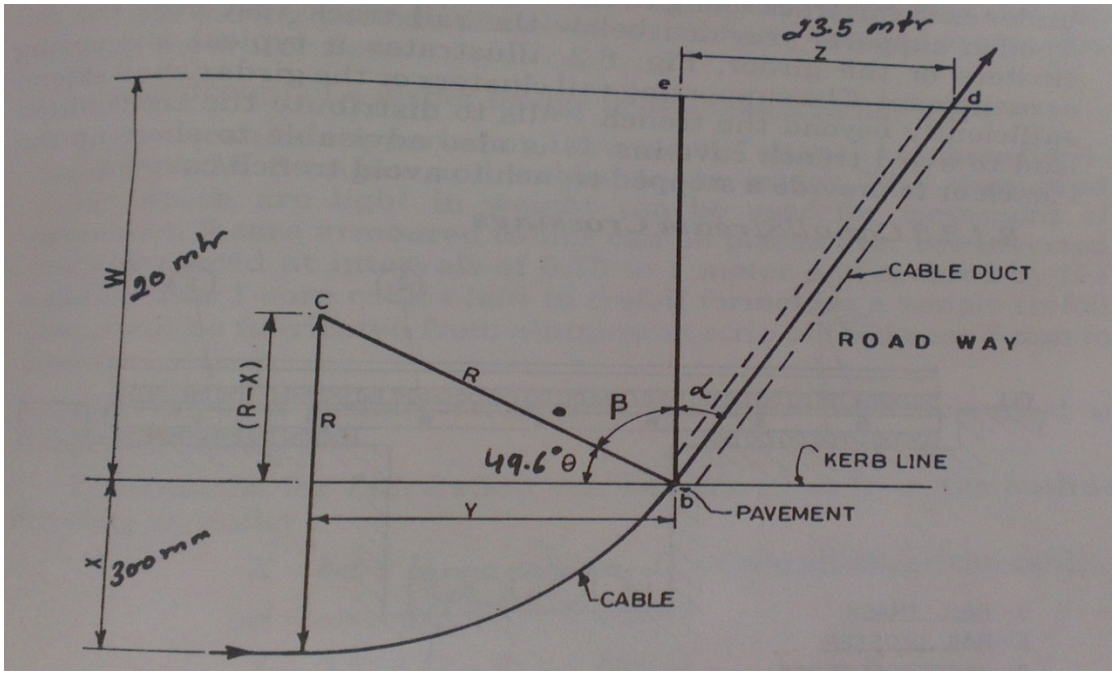
Stoneware/GI/CI/RCC/HDPE pipes are used for road crossing and for protection on poles only GI/metallic pipe shall be used. RCC pipes have high degree of mechanical strength and preferably used upto 33 kv applications. Minimum dia of pipe kept 1.5 times than the outer dia of cable. minimum diameter of pipe shall be 100 mm for single run of cable and minimum 150 mm for more than 01 cable run. Different voltage cable shall always pass through separate pipes. PCC bed of 100 mm thickness is required for stoneware pipes only. Top surface of pipe shall always be minimum 01 metre below the pavement level of Road. All metal pipes shall be properly bond with earthing station. Crossing shall be done askew to reduce the safe bending angle of cable. To maintain the safe bending radius , the road crossing angle can be calculated as below :

X = distance between road entry and cable
R = minimum required bending radius
α = angular alignment of pipe/duct
Distance deviation can be derived for pipe's far end

$\text{Sin}\theta = \frac{R-X}{R}$ …… eq (a)

α = 90-β
=90-(90-θ)
α = θ now Z = W.tanθ …… eq (b)

take an example (as shown in figure below)



Calculation for angle of pipe crossing

Voltage & size of cable - 33kv, 3 core, 400 sq.mm. XLPE cable
Distance X - 300 mm = 0.3 mtr
Road width, W - 20 mtr
Outer diameter of cable - 105 mm = 0.105 mtr
R, bending radius required - 12x0.105 = 1.26 mtr
Now from eq (a), Sinθ = (1.26-0.3)/1.26
= 0.76
And θ = 49.6 deg.
Putting values of W and θ in eq (b), we get
Z = 20tan49.6deg.
= 23.5 mtr

2.5 Trenching

Width of trench shall be minimum 350 mm or single run of cable. Inter axial space between 02 cable shall be 200 mm and minimum clearance between cable's axis and sides of trench shall be 150 mm. depth for LT cable shall be 750 mm and for 11 kv & 33 kv, it will be 900 mm and 1200 mm respectively.if there is tier formation in trenches than the vertical clearance between 02 tiers shall be 300 mm. trenching shall be in straight line and when direction has to be changed, there shall be a suitable curvature for sage bending of cables.

2.6 Cable laying

Cables up to dia 95 sq. mm can be removed from drum by flaking, not acceptable for higher sizes. cable shall always be uncoil by the help of jacks above 50 sq. mm. When cable is laying direct in ground then there shall be 75 mm bed of fine sand in bottom before laying. Then test for insulation resistance and continuity of cable. Cover the cable after testing 170 mm sand from base cushion. For multilayer cabling, sand cushioning shall be 300 mm between cables. A loop of approximate 3.0 mtr shall be kept on each termination as well as both sides of each joint. In very long span, cable may be looped at specified intervals. Protection cover by bricks/slates/tiles is placed above sand cushion with 50 mm extra cover on both sides of cable. Back filling earth shall be rammed and watered in the layers of 300 mm. bricks protection may be waived for LT cables if the depth is increased by 250 mm more than standard depth. Never install a cable with kinks or damaged armour.

Minimum bending radius	Single core cable	Multicore cable
Upto 1.1 KV	15D	12D
1.1 kv to 11 kv	15D	15D
Above 11 kv	20D	15D

Where D is the outer dia of cable

Bending radius of steel/HDPE duct kept minimum 1.5 metre.

Cable laying in trench

When single core cable is installed directly on surface, clamp shall be non-magnetic and shall not pass through any metallic pipe. Sag and kinks are not acceptable. If cable size exceeds 120 sq. mm MS flat are allowed to cradle with bolting on wall at interval of 600 mm. all mild steel components shall be galvanised of painted with red oxide.

In case of cable trays, coupler plate shall be 200 mm length with same material and specifications of channel of tray. Contact area between channel and coupler shall be scraped and removed for better earth continuity. Width of cable tray kept 30% higher for future expansion and shall be minimum size of 100 mm. MS flats of size 25 mm X 5 mm may be used as suspender for tray up to 450 mm. GI rods of 10 mm dia may be bolted to tray or on an angle support of 50 mm x 50 mm x 5 mm size. Tray should be earthed at both ends and cable shall be tied/clamped on suitable intervals. There shall be cable tags for identification of feeder at fix intervals.

When cable is entering in a building through pipe then the slope of pipe shall be downward from the building and pipe ends towards building shall be sealed after laying of cable.
If site temperature is below 3 deg. C, cable should be warmed up to minimum 10 degree C before laying. It shall be warmed with blowers in a closed room or tents for minimum 24 hours otherwise bending will damage the insulation and protective covering of cable.

2.7 Testing at site
Three types of fault may occur in underground cabling i.e. open circuit fault, short circuit fault and earth fault. To avoid these faults there are some tests carried out at site before laying and after laying of each cable span.
2.7.1 Before laying
Insulation resistance test, continuity test, earth fault test
2.7.2 After laying

- Insulation resistance test
- Continuity test
- Earth fault test
- DC pressure test for 15 minutes (if not possible than test for 01 minute with 1000 V megger for LT cable and with 2500/5000 V megger for HT cable.

2.8 Jointing
Before laying a cable, joint location must be identified. Is should lie in road crossings, water logging area, communication lines and any other main service's line. Joints shall be at staggered position by 2-3 metres when 02 or more cable has to be jointed. Before jointing, Aluminium conductor's oxide film shall be completely removed by scraping or flux. Joining shall always be done by a certified and experienced jointer. For jointing, there are various jointing & termination kits. Mainly used are heat shrink, cold shrink, push on, tapex and resin cast jointing kits. Procedure shall be strictly follows as per manufacturer's guidelines. After jointing and termination, DC high voltage test to be performed.

Heat shrink cable jointing

2.9 Route markers

GI/CI/Al plate on MS angle of 35mm x35mm x 6 mm of 600 mm length may be used for marker. It should be parallel to cable and kept at 300 mm from cable and at underground joints. Concrete markers can also be used and to be furnish above cable laid.

Cable route markers

3 Detailed cable installation plan

After cable installation, jointing and termination, a plan shall be prepared. It will include the following details:-

- Type of cable, cross sectional area, rated voltage, cable number and drum numbers.
- Year and month of laying
- Actual length between joints to joints and end to joints
- Location of cable and joints in relation to certain fix reference points
- Name of jointer
- Date of jointing
- Result of testing and measurement

Conclusion

Underground cabling are safer than overhead electrical lines and also gives aesthetic look to the projects. But underground installation work need higher attention and skills otherwise the performance of system may result unsatisfactory. The major points which are to pay major focus are bending angle, jointing, testing and protection for system as well as neighbourhoods

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