GUYANA POWER & LIGHT INCORPORATED

Technical Guidelines for Installing Directly Buried 13.8kV Cables

Engineering Designs & Standards Department – Engineering Services Division

Updated on September 22, 2021

Page Intentionally blank

Table of Contents

1. SCOPE

The following is a guide to installing directly buried 13.8kV cables.

2. APPLICABLE STANDARDS

Table 1: Applicable Standards

Item No.	ANSI/IEC/IEEE Standards	Title
1	IEEE 525	IEEE Guide for the Design and Installation of Cable Systems in Substations
2	IEEE 404	Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV
3	NESC	National Electrical Safety Code

In case of conflict, the order of precedence shall be:

- This Technical Guideline
- IEEE standards
- Other Applicable and Recognised Related Standards.

3. GENERAL

The proper design of cable systems requires the consideration of many factors. These factors include ambient temperature, conductor temperature, earth thermal resistivity, load factor, current loading, system fault level, voltage drop, system nominal voltage and grounding, method of installation, and number of conductors being installed.

The below guidelines are mainly based on IEEE 525 and focuses on the basic steps in directly burying 13.8kV armoured cables and do not consider cable spacing, route planning, surveying, environmental impact, working near energized equipment, considerations for work near traffic areas, testing, etc.

4. GENERAL INSTALLATION PRECAUTIONS

1) Pulling instructions for all cable should follow the cable manufacturer's recommendations.

2) Sufficient cable slack should be left in each manhole and temporarily supported so that the cable can be trained to its final location on racks, hangers, or trays along the sides of the manhole.

3) Cable joints should not be placed directly on racks or hangers (IEEE 404).

4) The use of single- or multi-roller cable sheaves of the proper radius should be used when installing cable around sharp corners or obstructions. Minimum bending radius should never be less than that recommended by the manufacturer.

5) Cables should be installed in trenches that have adequately sized bends, boxes, and fittings so that the cable manufacturer's minimum allowable bending radii and sidewall pressures for cable installations are not violated.

6) The ends of all cables should be properly sealed during and after installation to prevent moisture collection as ambient temperature and humidity change.

7) Reels should be stored upright on their flanges and handled in such a manner as to prevent deterioration of, or physical damage to, the reel or to the cable. During storage, the ends of the cables should be sealed against the entrance of moisture or contamination. Reels should be stored on solid ground to prevent the flanges from sinking into the earth.

8) Special care should be exercised during welding, soldering, and splicing operations to prevent damage to cables. If necessary, cables should be protected by fire-resistant material.

5. DIRECT BURIAL METHOD

Direct burial of cables is a method whereby cables are laid in an excavation in the earth with cables branching off to various pieces of equipment. The excavation is then backfilled. The depth of 13.8kV cable laying is 1m or guided by the latest revision of the NESC.

A general guide to cable laying for direct burial is as follows.

- The excavated trench is made with a depth of about 200mm below the required depth of cable laying and a width allowing at minimum 50mm space between the outer cables and the excavated trench walls.
- A layer of sand is usually installed below and above the cables to prevent mechanical damage. These layers shall be at minimum 200mm in depth each. Care should be exercised in backfilling to avoid large or sharp rocks, slag, or other harmful materials.
- A warning system to prevent accidental damage during future excavation is then placed on the sand fill. Several methods used are treated wood planks, a thin layer of concrete or concrete slabs. Untreated wood planks may attract termites, and overtreatment may result in leaching of chemicals harmful to the cables.
- A further layer of sand 100mm in depth is added.
- Brightly colored caution tape is then carefully laid along the length of the buried cables.
- Backfilling material is then used until the 0 level is reached. Spare cables or ducts may be installed before backfilling.
- Cable markers shall be tapered blocks with a base of width 10 inches and length 10 inches, cast from concrete and buried with its upper face 100mm above the natural ground level. Markers shall be provided at each end of an underground cable route, at all points where such routes deviate from a straight line and at joints in the cable. Markers shall be placed no more than 200m apart along the cable route. Marker positions shall be included in as built drawings.

It should be noted that this system has low initial cost, but does not lend itself to changes or additions, and provides limited protection against the environment. Damage to cables is more difficult to locate and repair in a direct burial system than in a permanent trench system.

6. CABLE LAYING

The following sections are guided by the Westernpower Underground Cable Installation Manual (2019) and IEEE 525 (2007).

6.1 DRUM INSPECTION AND MOUNTING PRIOR TO INSTALLATION.

The cable drum should be visually inspected for damage, which may have occurred during transport. The manufacturer's seal on the inner and outer cable ends should be examined and the condition of the sheath inspected for mechanical damage. If the cable is found defective it shall not be installed and the cable shall be replaced. During installation the cable should be carefully examined for any sign of damage as it leaves the drum. This is particularly important on the outer layers, where drum batten nails can cause damage. If it is necessary to roll the cable drum, it should be rolled in the direction indicated by the arrow on the drum. The drum should be mounted on jacks, cable trailer or cable stands. The cable can be rolled or pulled off the drum as indicated on the outside of the flange. Lighter cables may be laid by mounting the cable drum on its side on a truck-mounted turntable and laying the cable directly into the trench. When pulling from large drums, i.e. over 2m in diameter, the cable should be supported to prevent stressing the cable, from the drum to the trench on a suitable ramp. Alternatively, cables can be rolled directly into a trench from the drum mounted on an excavator moving along the trench. To limit the chance of damage to the cable prior to removing the cable drum battens, a check should be done to ensure that the drum-spindle is level and permits even rotation of the drum. During pulling there is a tendency for cable slack to accumulate on the drum. Slack shall be avoided and one possible method to achieve this is to limit drum rotation by using plank brake shoes against one or both flanges of the drum.

6.2 DRUM POSITIONING

Cable drums shall be positioned in line with the direction of cable pull.

6.3 Protection of Cables from Damage

Cables being drawn into place shall be kept clear of abrasive surfaces by suitable means, e.g. rollers, cable tiles, etc., to prevent any damage to the cable sheath. The cable must be placed in the trench without sustaining abrasion damage, and without allowing rocks etc., to fall into the trench. If the cable is hand flaked directly from cable drum or coil into final position or other method that does not drag the cable over ground cable rollers are not required.

On long cable runs where a cable changes direction, both horizontal and vertical, rollers shall be used to ensure a smooth pull and avoid damage to the cable. Cables, which are pulled into position by a winch, must use suitable cable stockings and swivels to prevent damage.

If the cable manufacturer's recommended maximum pulling tension, sidewall pressure, or the minimum bending or training radius is violated, damage could occur to the cable conductor, insulation, shield, or jacket. This could lead to premature failure and/or poor life-cycle operation.

Cables should be sealed before pulling and resealed after pulling, regardless of location.

If water has entered the cable, a vacuum should be pulled on the cable or the cable should be purged with nitrogen to extract the water, and tested for dryness.

6.4 Cable Pulling Tension

The maximum allowable pulling tension is the minimum value of *T*max from the applicable following guidelines, unless otherwise indicated by the cable manufacturer.

The maximum tension on an individual conductor should not exceed

$$\boldsymbol{T}\text{cond} = K \times \boldsymbol{A}$$

where

*T*cond is the maximum allowable pulling tension on individual conductor, in newtons (pounds)

A is the cross-sectional area of each conductor in square millimeters (mm2) (kcmil)

K equals 70 N/mm2 (8 lb/kcmil) for annealed copper and hard aluminum

K equals 52.5 N/mm2 (6 lb/kcmil) for 3/4 hard aluminum

When pulling together two or three conductors of equal size, the pulling tension should not exceed twice the

maximum tension of an individual conductor, i.e.,

$$T\ \text{max} = 2 \times T\text{cond}$$

When pulling more than three conductors of equal size together, the pulling tension should not exceed 60%

of the maximum tension of an individual conductor, times the number of conductors (“N”), i.e.,

$$T\ \text{max} = 0.6 \times N \times T\ \text{cond}$$

When pulling using a pulling eye, the maximum tension for a single-conductor cable should not exceed 22.2 kN (5000 lb), and the maximum tension for two or more conductors should not exceed 26.7 kN (6000 lb). The cable manufacturer should be consulted when tensions exceeding these limits are expected.

When pulling by basket grip over a nonleaded jacketed cable, the pulling tension should not exceed 4.45 kN (1000 lb).

6.5 MINIMUM BENDING RADIUS

The minimum bending radius is the minimum radius to which a cable can be bent while under a pulling tension, providing the maximum sidewall pressure is not exceeded. The values given are usually stated as a multiple of cable diameter and are a function of the cable diameter, and whether the cable is nonshielded, shielded, armored, or single or multiple conductor. Guidance for minimum bending radii can be obtained from the NEC or the cable manufacturer.

End of Technical Guideline