A.1.1.

Design and commissioning test of a 230-kV cross-linked polyethylene insulated cable system

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Abstract: This paper describes design and commissioning procedures for a 230-kV cross-linked polyethylene insulated cable installed in an urban duct system environment. Through literature review and calculation, the authors defined two design methods for insulation thickness—for low and high stress. Design criteria were identified for joint connections, mechanical forces at low temperatures, training of the cable, and pulling spans. In addition, a new method of field commissioning was explored.

Keywords : cross-linked polyethylene insulated cable, XLPE, commissioning tests, variable frequency test equipment

1. Introduction

The Los Angeles Department of Water and Power (LADWP) recently constructed a new 230-kV transmission line between the Toluca and Hollywood substations in Los Angeles, California. The connection consists of an underground power cable and an overhead line. The underground portion of the line is one circuit of the first 230-kV cross-linked polyethylene (XLPE) cable in Los Angeles and has a 400-MW transmission capacity (see Figure 1).

Figure 1
230-kV cable system installed in Los Angeles

The cable construction includes a 2500 Kcmil 5-segment copper conductor, 1060 mils XLPE insulation, 130 mils lead sheath, and 130 mils polyethylene jacket (see Figure 2). In addition, optical fibers were incorporated into the cable to monitor temperature and other conditions. The route length is 5.1 miles (8.2 km). The cables were installed in underground ducts, and joints were installed at 20 manhole locations along the route. At both ends of the route, outdoor terminations were installed. Since the cable route included a change in elevation, rachet devices were applied in some manholes, especially at steep slopes, to prevent the cable from slipping down the ducts due to expansion and contraction caused by the load cycles.

2. Insulation thickness

The accepted design methods for insulation thickness are based on maximum and average stress. The design for the Los Angeles project was based on two methods. The selected insulation thickness was chosen to satisfy both design criteria listed below.

2.1 Traditional method

One straightforward method is outlined in [1] as follows.

$$t = V_d / E_d \text{ , or } t = V_{imp} / E_{d\,imp} \qquad [1]$$

Where:

- t = insulation thickness
- $V_d = K_1 \cdot K_t \cdot K_d \cdot V_{ac} / \sqrt{3}$
- K_1 = over voltage or safety factor
  - 1.15 for AC and
  - 1.1 for Impulse
- K_t = temperature factor
  - 1.25 for both AC and Impulse
- K_d = aging or deterioration factor

The value of K_d needs some explanation: Both E_d and K_d are determined from the statistical data, either from service or experiments. Several