EMERGENCY CONDITIONS APPLIED TO TRIPLEX MEDIUM-VOLTAGE XLPE CABLES HAVING FLAT STRAP NEUTRALS

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ABSTRACT

The physical behavior and electrical performance of triplex medium-voltage XLPE cables with flat strap neutrals were studied during and after simulated emergency conditions. The main goal was to evaluate the influence of the direction of the neutrals and triplex cable assembly (right- or left-hand lay),as well as the neutral coverage over the insulation shield (75% and 100%). The cables were installed in underground conduits, submitted to cycling temperatures up to 130°C at the conductor, and their angular and longitudinal displacements were recorded. After the specification limit of the 1500-hours cumulative emergency overload, the cables were retrieved, examined and subjected to AC breakdown. The results indicate clearly that cables with neutrals with a left-hand direction are the less physically affected and have the greatest ACBD strength.

KEYWORDS

Temperature, cables, flat strap neutrals, performance.

INTRODUCTION

In underground distribution networks, cross-linked polyethylene (XLPE) extruded cables are rated for a maximum operating temperature of 90°C and an emergency temperature of 130°C [1,2]. Specifications also give a maximum on the emergency duration of 1500 hours cumulative during the lifetime of the cable. In practice, the operating conditions are usually below these limits, whereas several studies have shown that these cables can sustain greater temperatures without affecting their properties and even in some cases improving them [3-5]. However, concerns still remain about operating cables with flat strap neutrals at these temperatures in a duct bank. This type of cable is commonly used in downtown areas as they can fit in smaller duct diameters and also for PILC cable replacement. Kellow and al [6] have in fact demonstrated that 28-kV XLPE three single-phase cables, with an aluminum conductor and copper flat strap neutrals covering 100% of the cable's outer surface, can buckle or twist severely when submitted to conductor temperatures up to 130°C. The observed deformations were mainly explained in terms of the considerable thermal expansion differential between the insulation and the neutral straps. However, this study did not cover cables with copper conductors or the influence of the direction of neutrals, as well as the triplex assembly (right- and left-hand) on the thermo-mechanical and electrical performance of the cable at these temperatures. Currently, this type of cable has only a copper conductor to increase its loading capability, and the neutral direction is no longer specified in ICEA and CSA specifications [1,2].

The work reported here, besides investigating all the previous parameters in a duct bank configuration with actual-size cables, will also consider the coverage of two types of neutral straps and particularly temperature cycling. Furthermore, since XLPE becomes soft over ~90°C and is not totally cross-linked, the time or emergency duration parameter is also emphasized in the study. The AC (60Hz) breakdown strength (ACBD) characteristic is used to evaluate the cable's electrical performance after 1500 hours under emergency conditions.

EXPERIMENTAL

Cables

The cables are new three-phases triplex cables, rated 28 kV, tree-retardant XLPE insulated, and with a 350 kcmil (175 mm²) compact copper conductor, as shown in Fig.1.

Figure 1 – Cross-section (left) of the cable with flat strap neutrals, 100% coverage, with a left-hand direction of the lay. Example (right) of the left-hand direction of the triplex assembly for cable LL before installation with the thermocouple wires running in middle.

Four cable constructions were selected:

- **Cable RR**: with tin-coated flat strap copper neutrals (28 strips, 0,66 x 3,15 mm section), 100% coverage over the insulation shield, right-hand for the direction of the lay (R) and also for the of the triplex assembly one (R).
- **Cable RR75**: with tin-coated flat strap copper neutrals (17 strips, 0,89 x 3,81 mm section), 75% coverage over the insulation shield, right-hand (R) for the direction of the lay and also for the one of the triplex assembly (R).
- **Cable LR**: with tin-coated flat strap copper neutrals (20 strips, 0,66 x 4,57 mm section), 100% coverage over the insulation shield, left-hand (L) for the direction of the lay