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The paper presents an analysis of the behaviour of different kinds of joints installed in open air conditions, in case of fire due to internal short circuit. Thermal behaviour of open air joints and cable bunches has also been investigated with high speed camera and thermovision assessment, focusing on self-extinction and fire propagation of the joints and the cable tested. After having focused on the real behaviour of different kinds of joints the paper describes the possibilities offered by different means of fire resistant coverings.

Introduction

The length of the Enel MV network is about 300,000 km, 35% of which is formed by underground cables. The MV cable distribution is mostly made up of impregnated lead sheath paper cables; in the past belted cables were layered until 15 kV while for 20 kV lines, three lead core cables under a single PVC sheath were used. Several kinds of joint of different technology were used and are still in service.

The Enel harmonization makes provision for three single core paper cables pre-assembled type, with nominal voltage 12/20 kV, to be used on 20 kV lines as well as on lines with lower voltages.

In 1993 Enel harmonized the following kinds of unipolar joints for paper cables:
- paper tapes joint protected with injected resin;
- paper tapes joint with lead sleeve filled with poured compound and protected with cast resin.

In 1993 HEPR cables were harmonized and introduced in the MV network; shrinkable accessories (both heat and cold technology) were harmonized and introduced too.

As already mentioned the length of MV cable network is about 100,000 km; in most cases cables are buried and protected against damage using bent cement tiles or recycled PVC plates. However, cables can also be laid, especially in large towns, in tunnels, underground passages and so on; in such environments the brake out of fire and its propagation are possible as air is allowed to circulate.

Recently, in a tunnel coming out from a 150/20 kV substation the components of a joint caught fire as the consequence of an internal earth fault and the propagation of fire to the nearby cables caused temporary loss of service and damage.

Taking into account the above accident a research has been necessary to analyze the behaviour of joints in case of fault, to quantify the electrical parameters able to provoke their fire and to verify the efficiency of some of the fire resistant coverings available on the market.

Test parameters

An urban underground cable network fed by an HV/MV substation can be 150-200 km long with an area of 15-20 km². The earth fault current of a network fed by the same transformer is given by the following formula:

\[ I = \left(0.003xL_1 + 0.2xL_2\right)xV \]  \hspace{1cm} (1)

where:
- \( L_1 \) = overhead lines length, (km);
- \( L_2 \) = underground lines length, (km);
- \( V \) = nominal voltage, \( U_0 \) (kV)

The typical values of the above current are comprised between 300 and 400 A. To evaluate the behaviour of the joints at the maximum stress conditions, a test current of 500 A was chosen.

According to the service and nominal voltage of the testing joints, the 12 kV value had been expected as test voltage. Moreover, due to the reasons later described, the tests were carried out at 15 kV.