SPECIAL BONDING AND EARTHING OF CABLES FOR A 230KV THREE PHASE SYSTEM WITH FOUR CABLES

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ABSTRACT

Cross transposition of cables can mitigate the rising of sheath losses. Usually the special bonding system is designed for a three-phase system with three cables; however, due to reliability conditions imposed by the regulatory agency in Brazil in the case of TPAE (Transmissora Portoalegrense de Energia) in Brazil it was necessary to include the fourth cable (spare cable) in the system.

This paper describes the main aspects of the problem that arises due to the presence of the fourth cable integrated to the three-phase system by analysing the current rating and losses and presents the development of the link-box, cable transposition and connections for a three-phase system with four cables.

KEYWORDS

EHV Cable, Special Bonding, Cross-bonding.

I INTRODUCTION

The underground transmission in Brazil began in middle 40's when the first HPOF (High Pressure Oil Filled) has been installed in Rio de Janeiro and São Paulo cities. In early 60's SCOF (Self-Contained Oil Filled) cables replaced HPOF cables. Recently, from 2000 up to now almost 100% of new installations are designed using solid dielectric cables, especially XLPE insulation.

The most of old installation were direct buried in single circuits and the utilities specified four cables per circuit (one cable as spare of other three). Even if the fourth cable remain out of service its lead sheath and those of the other cables would be source of energy losses and them must be taken inconsideration during ampacity calculation.

Cross transposition of the cable could mitigate the rising of sheath losses, but not avoiding it and finally special bonding sheath as cross-bonding and single point rise up with further difficulties to be designed and installed.

We aim to describe the main aspects of the problem bring up due the presence of the fourth cable in a 230kV, 12km underground transmission line and solutions implemented in the city of Porto Alegre in Brazil.

II AMPACITIES OF DIRECT BURIED CABLES

The ampacities of power cables began with pioneer works of Neher and McGrath [1] and presently is well formalized in several documents with special reference of IEC 60287 – Calculation of the current rating [2]. The maximum ampacity for direct buried cable can be calculated according:

$$I = \left[\frac{\Delta\theta - W_d\left[0{,}5T_1 + T_2 + T_3 + T_4\right]}{R\left[T_1 + (1+\lambda)(T_2 + T_3 + T_4)\right]} \right]^{0,5} \quad (1)$$

Where:

I - current flowing in one conductor (A);

Δθ - conductor temperature rise above the ambient temperature (K);

W_d - dielectric loss per unit length for the insulation surrounding the conductor (W/m);

T_1 - thermal resistance per unit length between one conductor and the sheath (K.m/W);

T_2 - thermal resistance per unit length of the bedding between sheath and armour (K.m/W);

T_3 - thermal resistance per unit length of the external serving of the cable (K.m/W);

T_4 - thermal resistance per unit length between the cable surface and the surrounding medium (K.m/W);

R - alternating current resistance per unit length of the conductor at maximum operating temperature (Ω/m);

λ - ratio of losses in the metal sheath to total losses in all conductors in that cable.

In (1) the parameters λ and W_d play an important role in the ultimate value of ampacity. While W_d is out of scope of this paper, *λ* will be given special attention mainly when the fourth cable be introduced in cable flat formation.

Except for very short long length power cables must be transposed avoiding different current in each cable due to different magnetic flux linkage by single sheath. When the cables are transposed there will have a magnetic flux compensation in its sheath and the result is a balanced current correlated to flux linkage. In the most case for transposed cables (phase and sheath simultaneously), the ratio of sheath losses and phase losses (λ) is calculated by

$$\lambda = \frac{W_s}{W_c} = \frac{R_s}{R_c} \cdot \left(\frac{\omega^2 M^2}{R_s^2 + \omega^2 M^2} \right) \quad (2)$$

Where:

R_c alternating current resistance of conductor at its maximum operating temperature, Ω/km;

R_s a.c. resistance of sheath, Ω/km;

M Mutual inductance;