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A.9.4.

Cable crossings

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Abstract : This paper introduces a method for the calculation of the thermal rating of underground links, where crossing linear heat sources, such as other electrical links or steam pipes, are involved. Taking into account the longitudinal heat flux in the cable metallic screen, cyclic loads and possible soil drying are the main features dealt with.

Keywords : underground link, thermal rating, crossing

Résumé : Cet article porte sur le dimensionnement thermique des liaisons souterraines, croisées par des sources de chaleur linéaires telles que d'autres liaisons électriques ou des canalisations de chauffage urbain. Il traite en particulier de la prise en compte du flux de chaleur longitudinal dans l'écran, de charges cycliques et du dessèchement éventuel du sol.

Mots clés : Liaisons souterraine, dimensionnement thermique , croisement

1 - Introduction

The current rating of underground links has to take into account the thermal influence of heat sources, such as steam pipes or electrical links, installed in its vicinity : neglecting the influence of a crossing heat source may lead to detrimental overheating of the cable, whereas applying formulae which are valid for parallel routes would turn into oversizing the cable.

The difference between parallelism and crossing lies in the longitudinal heat dissipation in the cable, which does not occur in case of parallel routes. In case of a crossing, due to the varying temperature rise along the cable length, a longitudinal heat flux is generated in the conductor, which leads to a reduction of the conductor temperature rise at the crossing.

Algorithms allowing to take into account the longitudinal heat dissipation in the cable were presented [1,2,3,4]. This paper focuses on studies intended to extend this algorithm when cyclic loads or soil drying around cables are concerned.

2 – Derating factor

The temperature of the core, along its route, may be expressed as a function of Joule losses W_c and the temperature rise of the core $\Delta\theta_c(z)$, due to the crossing heat source :

$$\theta_c(z) = \theta_{amb} + \Delta\theta_d + W_c.T + \Delta\theta_c(z) \qquad [1]$$

It follows that the derating factor i.e. the multiplying factor to be applied to the cable rating when isolated, to get the cable rating, taking into account the crossing heat source, may be derived as :

$$F = \sqrt{1 - \frac{\Delta\theta_c(0)}{\theta_{\max} - \theta_{amb} - \Delta\theta_d}}$$

where $\Delta\theta_c(0)$ is the core overheating due to the crossing source at the crossing point (z=0), θ_{max} is the core maximum permissible temperature and $\Delta\theta_d$ is the core temperature rise due to dielectric losses W_d :

$$\Delta\theta_d = W_d \cdot \left(T_r - \frac{T_1}{2} \right)$$

T, T_r and T_1 being thermal resistances as defined in the list of symbols.

3 – Basic Equations

Let us consider a small length Δz in cable route, as illustrated in figure 1.
For the core, the energy conservation principle and the expression of the longitudinal heat flux according to Fourier's law turn into :

$$W_c(z).\Delta z + W_L(z - \Delta z) = W_{cr}(z).\Delta z + W_L(z)$$

$$W_L(z) = -\frac{1}{T_{lc}} \cdot \frac{\partial\theta_c(z)}{\partial z} \qquad with: \; T_{lc} = \frac{\rho_c}{S}$$

Therefore :

$$(W_{cr} - W_c) - \frac{1}{T_{lc}} \cdot \frac{\partial^2\theta_c}{\partial z^2} = 0 \qquad [2]$$