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Current rating of cables installed in tunnels

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Abstract
Where several cable circuits are installed, together, within a tunnel (for instance, where distribution links are laid close to high voltage feeders), the standard IEC cable current rating method is not so easy to handle, for the ambient temperature in the tunnel cannot be predicted.

This paper reports on some studies and tests carried out to enable an improved rating of cables installed in a tunnel.

Key-words : underground links, thermal rating, tunnel.

Résumé
Lorsque plusieurs circuits de câbles sont installés dans une même galerie (par exemple, lorsque des câbles de distribution sont placées à proximité de liaisons haute tension), le dimensionnement thermique des câbles n'est pas simple à effectuer en utilisant la méthode préconisée par la CEI, car on n'est pas en mesure de prédéterminer la température ambiante de la galerie.
Cet article présente les études et les essais réalisés afin de permettre un meilleur dimensionnement des câbles en galerie.

Mots-clés : liaisons souterraines, dimensionnement thermique, galerie.

1 – Introduction.

In the IEC approach [1], the ambient temperature within the tunnel is required to derive the ampacities of the various circuits installed in the tunnel.

But there is no guidance for evaluating the ambient temperature from the heat dissipated by the circuits, as it is the case for installations in unfilled flush troughs.

In addition, to take into account the two involved heat transfer ways, convection and radiation, a single heat transfer coefficient is used. This coefficient, which is a function of the cable diameter, is determined from 3 parameters which depend only on cable installation and are given for some typical arrangements.

To assess and extend the range of applicability of IEC heat transfer coefficients, two studies were carried out.

The main models for heat transfer mechanisms in air and also in the soil around the tunnel, as well as the different approaches that may be found in the literature were reviewed on and compared, to work out analytical solutions.

In a parallel way, calculations were performed, using numerical methods, for many laying conditions : a single cable (single-core cables, 63 kV or 400 kV as nominal voltages) with various distances to the tunnel walls, 3 cables in trefoil or flat formation, different tunnel sizes … These calculations were intended as a validation of the analytical approach, which is easier to deal with.

To get confidence in the performances of these calculations, a full-scale test equipment was set up to get experimental temperature rises with actual cable installations.

2 – Heat transfer Models

For cables installed in air, conduction is the main heat transfer mechanism inside the cable, whereas the energy outflow is due to convection and net radiation from the cable surface (see figure 1)

The energy balance equation at the surface of the cable is :

$$W = W_{S,conv} + W_{S,ray}$$

W refers to the cable losses, $W_{S,\,conv}$ and $W_{S,\,ray}$ to the heat transfer rates due to convection and radiation, respectively.