Calculation of the current ratings of cable systems laid in concrete troughs filled with sand

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ABSTRACT

Buried concrete troughs are used in substations and industrial sites. The different thermal resistivity of their components (prefabricated concrete gutter, covering slab, filling sand) compared with that of the surrounding soil, does not allow a direct calculation of the current ratings.

A simple thermal model is proposed to match the requirements of the analytic equations of the IEC 60287 standards. The model was validated by two useful techniques: Finite Element Method and conformal transformation. A worked example illustrates the calculation, as CIGRE TB 880 does for similar configurations, and figures are provided for an educational purpose.

KEYWORDS

Power cable systems, concrete through, current ratings, IEC 60287, thermal modelling, calculation, Finite Element Method (FEM), conformal transformation.

INTRODUCTION

The calculation of current ratings of power cable systems is based on the modelling of the cable and its environment. IEC 60287 series [1][2] provides analytic expressions to calculate among others the thermal resistance of the surrounding medium, depending on the installation technique. With little development, it is easy to cover the case of buried cables (in the native soil or in a backfill), cables in ducts (embedded in concrete or not), cables in unfilled troughs with the top flush with the soil surface, cables in free air (protected from direct solar radiation or not). These configurations have been extensively described and verified in CIGRE TB 880 [3].

Other installation techniques involving regions of different materials can be solved with more sophisticated tools (e.g. conformal transformation, finite element method - FEM). However, proper approximations can be applied to basic geometries to solve with a good accuracy some of these configurations.

A simple model is presented to calculate an analytical expression of the external thermal resistance T_{4tr} of concrete troughs (a prefabricated gutter with a cover) filled with sand. The methodology, the equations and two validation techniques are discussed.

THROUGH FILLED WITH SAND

Before the extensive use of plastic ducts, concrete troughs were installed in France for transmission cables, especially in substations at a shallow depth.

Figure 1 shows the vintage cross-sectional view of two such troughs, combined to two ducts embedded in concrete in the middle.

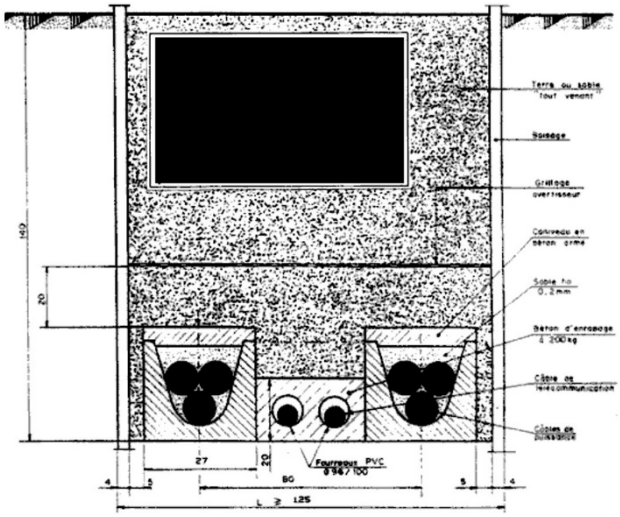

Figure 1: Cross-sectional view of a trench with troughs

The ability to calculate current ratings must be maintained for existing power systems, when the operating policy is evolving or to manage temporary networks reconfigurations.

SCHEMATIC DIAGRAM OF A CONCRETE TROUGH

The trough is assumed as a prefabricated concrete gutter with a cover:

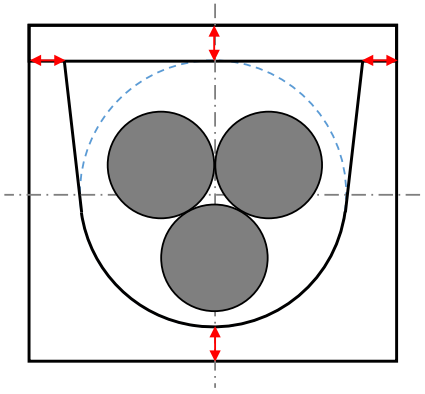

Figure 2: Schematic view of the cables in trough

It is designed according to the following criteria:

- The circular cross-section of the gutter is centred in the rectangular cross-section of the whole,
- The same thickness is adopted for the cover, the bottom of the gutter and the top of the walls on which