CURRENT RATING OF CABLES INSTALLED IN PLASTIC DUCTS

Christophe MOREAU, EDF R&D, (France), christophe.moreau@edf.fr
Ludovic COURSET, RTE / CNER, (France), ludovic.courset@rte-france.com

ABSTRACT

In relation with current rating calculation described in IEC 60287-2-1 Standard ([1]), this paper shows the results of investigations carried out in order to determine U, V and Y coefficients adapted to the installation of the underground cables in plastic ducts.

The influence of various parameters as the ratio between the internal diameter of the duct and the external diameter of the cable and the nature of the duct are discussed.
Both ducts filled with air and with water are considered.

KEYWORDS

Cable, plastic duct, current rating

INTRODUCTION

With respect to underground cables installed in ducts, the bases of current rating calculation in steady state condition were established in the 1950s by Neher, Buller and McGrath and supplemented in experiments by the data of Greebler and Barnett ([2], [3], [4]). They result from an approach combined between the theory of heat transfer (with some simplifying assumptions) and many experimental data. At that time, the ducts were made with metal, concrete, fibre or earthenware.

Nowadays, the installation of HV underground cables in ducts is commonly used. It makes it possible to proceed to the complete link construction in opening only small sections of trenches at the same time. Consequently, it largely facilitates the establishment of underground links in urban area. Moreover, it has advantages in case of possible replacement or later in dismantling.

IEC 60287-2-1 standard uses the results of the studies undertaken in the 1950s and proposes an empirical formula for the evaluation of thermal resistance between the cable and the duct. This resistance is conventionally symbolized T'4. The formula contains 3 coefficients U, V, and Y which are fixed for a given installation condition.

Up to now, there is no standard value for U, V, Y for the installations using plastic ducts (PVC or HDPE) whereas this type of installation is very largely used.

THERMAL EXCHANGES IN DUCTS

IEC formulae

The thermal resistance between a cable and a duct (T'_4) in steady state condition is given by the formulae (1) issued from IEC 60287-2-1.

$$T'_4 = \frac{U}{1 + 0{,}1\,(V + Y\,\theta_m)\,D_e} \qquad (1)$$

where:

- U, V, Y are constants, depending on the installation conditions
- D_e is the external diameter of the cable (mm)
- θ_m is the mean temperature of the medium filling the space between cable and duct (°C)

This formulae is nowadays widely accepted by the community of cable experts and used in many companies to design underground links. Even if the use of more elaborated software tools (i.e. finite element simulation) could provide a more accurate result there is still a need for simple and agreed formulas as far as they can provide a quick and rather good result.

Basic assumptions

In general heat transfer between a cable and a duct through a filling medium is due to conduction, convection and radiation. Usually, the cable is laid on the bottom of the duct and the theoretical solution of heat transfer is not simple.

In order to combine the thermal theory of exchange with experimental data some simplifying assumptions have been applied:

- Cable and duct are assumed to be concentric cylinders
- External surface of the cable is assumed to be isothermal (outer covering temperature is constant)
- Internal surface of the duct is assumed to be isothermal
- The cable and duct are long enough (no end effects)
- Convection is natural

Expression of thermal resistances

The total heat flow through the filling medium is given by:

$$W_{total} = W_{conduction} + W_{convection} + W_{radiation} \qquad (2)$$

Dividing each part of (2) by the difference of temperature in