Chapter 7
De-Rating Factor Due to the Dry-Band Formation

ABSTRACT

This chapter investigated the factors affecting the cable loading such as dry band formation, conductor temperature, sheath temperature, cable jacket temperature and exterior duct temperature and de-rating factor for different soil under testing. Applications are carried out using different ratings of distribution cables.

7.1 DE-RATING FACTOR DEFINITION AND CALCULATION

Formation of dry zones around the power cables which affect the cable loading is reported by KEMA Report. (1981) and Koopmans, G., & Gouda, O. E. (1985).

By De-rating Factor we mean the ratio between current ampacity of the cable with dry band formation and the cable ampacity assuming there is no dry band is formed.

Publication of IEC 60 287-1-3 (1982) gives formula to calculate the maximum current carrying capacity of underground power cables without taking the dry band into consideration as given in equation 1

$$I = \sqrt{\frac{\Delta\theta - W_d\{0.5T_1 + n(T_2 + T_3 + T_4)\}}{R_{ac}\{T_1 + n(1+\lambda_1)T_2 + n(1+\lambda_1+\lambda_2)(T_3 + T_4)\}}} \quad (1)$$

In IEC 60 287-1-3 (1982) the dry band formation is considered in the calculations of maximum current carrying capacity of the underground power cables according to the following formulas:

$$I = \sqrt{\frac{\Delta\theta - W_d\{0.5T_1 + n(T_2 + T_3 + vT_4)\} + (v-1)\Delta\theta_x}{R_{ac}\{T_1 + n(1+\lambda_1)T_2 + n(1+\lambda_1+\lambda_2)(T_3 + vT_4)\}}} \quad (2)$$

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Where:

$\theta_c - \theta_a = \Delta\theta$ is the difference between the conductor temperature θ_c and the ambient temperature θ_a °C, number of load carrying conductors in the cable is n (they are of equal size and carrying the same load), W_d is the Dielectric loss per unit length for the insulation surrounding the conductor per phase, R_{ac} is the Alternating current resistance per unit length of the conductor at its maximum operating temperature $(/m)$, T_1 is the Thermal resistance per unit length per core between conductor and sheath (°C.m/W), T_2 is the Thermal resistance per unit length of bedding between sheath and armour (°C.m/W), T_3 is the Thermal resistance per unit length of the external serving of the cable (C°m/w), T_4 is the Thermal resistance per unit length between the cable surface and the surrounding soil (°C.m/W), λ_1 is the Ratio of losses in the metal sheath to total losses in all conductors in that cable, and λ_2 is the Ratio of armouring losses to conductors total losses.

To calculate the maximum current carrying capacity of the underground power cables or the cable ampacity in case of dry band formation the ratio between the dry and moist gives resistivites of the backfill soil (υ) and the difference between the critical temperature of boundary between the moist and the dry zones in ^{O}C and ambient temperature ($\theta_X - \theta_a$) have to be obtained.

7.1.1 The Ratio between Dry and Moist Zones Thermal Resisitivities of the Backfill Soil (υ) and the Temperature Difference between Moist and Dry Zones and Ambient Temperature ($\theta_X - \theta_a$)

From the curves given in chapter 6 the thermal resistivities of moist and dry zones for difference types of soil samples under testing can be obtained where the suction tension (Pf) is ∞ and the heat flux density is Qh=255 W/m$^{2.}$ Some tests are carried out by varying the heat flux density to be 468 W/m^2 but it is noticed that there is no essential variation in ($\theta_X - \theta_a$) or (υ). The following results are obtained by Gouda, O. E. (1987) and Zaki, M. (1993).

Table 1 gives ($\theta_X - \theta_a$) and $\upsilon = \frac{\gamma_{dry}}{\gamma_{wet}}$ for the soil under testing.

From the so many tests carried out on different soils used as backfill materials it is noticed that the critical temperature for dry band formation depends on the soil components but it independent on the heat flux density. Also the ratio between the dry and wet thermal resistivities depends on the soil type.

7.1.2 Calculations of the Underground Power Cables Ampacity by IEC 60287-1-3

The ampacity of cable loadings with and without dry band formation can be calculated by IEC 60287-1-3 gives in items. $\Delta\theta_X$ and υ are taken from table 1 for different types of sands.

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