

Chapter 9

Effect of Dry–Zone Formation around Underground Power Cables on Their Ratings

ABSTRACT

Current ratings of buried cables are determined by the characteristics of surrounding soils and cable properties as given in IEC 60287-1-3 (1982). In this standard the soil thermal resistivity of the surrounding soil is supposed to be varies from 0.5 °C m/w to 1.2 °C m/w but under loading the heat dissipated from underground power cables increases the soil thermal resistivity and this may leads to cable thermal failure and thermal instability of the soil around the underground cables. For this reason de-rating factors for cable loading taking the dry zone formation into consideration has to be considered during distribution cable network design. Several approaches have been adopted to establish current ratings of buried cables based on constant values of soil thermal conductivities. Mathematical models are suggested by many researches to study the drying out phenomenon around underground power cables. In this chapter de-rating factor for underground power cables taking dry zone formation into account is calculated depending on IEC 60287-1-3 (1982). This chapter also contains an experimental work carried out on different types of soils to investigate the formation of dry zone phenomena under loading by heat source simulates the underground cables.

9.1 EXPERIMENTAL STUDY

9.1.1 Soil Samples Used in Testing

Several experiments are carried out on different types of natural soils to study the dry out zone formation under different loadings conditions. Six types of natural soils are investigated for studying the drying out phenomena and the thermal behaviour of the soil around the power cables. These types of soil can be classified in composition as given in table 1.

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Table 1. Classification for investigated soil types

Soil type	Weight percentage (%)				Classification
	Gravel	Sand	Silt	Clay	
Sand1	1.5	88.5	10	-	Very coarse sand, poor in gravel, moderately poor in silt
Sand2	2	88.5	9.5	-	Moderately fine sand, poor in gravel, moderately poor in silt
Sand3	13	84	3	-	Medium to coarse sand, some gravel and traces of silt
Sand4	8	92	-	-	Medium to coarse sand, some gravel
Silty sand	8	60	30	-	Medium to coarse sand, some gravel
Clayey Silty sand	3	37	30	30	Medium to coarse sand, some gravel

9.1.2 Thermal Test for Studying the Drying Out Phenomena in Sandy Soils

A. Experimental Setup

The sample under testing is contained in a cylinder of material with a diameter of 100 mm as given in (Figure 2). The height of the soil sample is 100mm. In the top part, a heat flux of known magnitude is introduced in a downward direction; this flux is measured by means of a calibrated heat flux meter. The bottom of the sample is in contact with a porous slab of sintered Pyrex glass with small pores (pores diameter 5 mm). This filter plate is glued on to a vessel of transparent plastic material completely filled with water a flexible tub connects the vessel with a levelling bottle, the water level in this bottle function as an artificial ground water table. The cylinder containing the soil sample has been sealed off by an o-ring against the top wall of the insulated level. By this arrangement the moisture tension and thus water content can be adjusted. A number of their couples are placed with the walls at the axis of the sample that provide a possibility of measuring the temperature distribution at different points of the soil sample.

B. Test Results

The temperature distribution at different points in the investigated samples, sand1, sand 2, sand 3, sand 4, silty sand and clayey silty sand against distance are given in (Figures 1 to 6). The samples under testing are heated under the stated condition for heat flux density Q_h and suction tension $p_f = \infty$, as shown in figures there are two slopes for the temperature distance relationship with respect to time, i.e. there are two zones, zone1 near the heat source represents the cable and this is the drying out zone and zone 2 which is

$$\sigma = \frac{\left(\frac{dT}{dZ} \right)}{Q_h} \quad (1)$$

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