Document Title: Description, AN, Producing Thermal Dryout Curves for Buried Cable Applications		Part # and Rev. 13994-02 Release Date: 5-25-12	
Rev.	Description	Revision By	Date
-02	Updated to new Thermal layout	REB	5-25-12

Production Filename: 13994 (In Product Library)

Path to Working Files: DecaDoc\Application Notes\Master\Thermal Properties\13994-02 AN Producing Thermal Dryout Curves

Dimensions: 8.5 inch wide, 11 inch tall

Material: Paper, 92 Bright White or better, 75g/m² or heavier

Colors: Color Print on White

Printer: HP Color LaserJet 8550

Finish: None

Adhesive: None

Special Notes: Illustrations are Ref Only ** Not to Scale ** (Shown page 1 of 4)

DECAGONTHERMAL
BY DECAGON DEVICES, INC.

Application Note

Producing Thermal Dryout Curves for Buried Cable Applications

The relationship between water content and soil thermal conductivity or resistivity is often termed a thermal dryout curve (resistivity is just the reciprocal of conductivity). The thermal conductivity of a soil depends strongly on water content, but also depends on temperature, bulk density and soil composition. To speak of the thermal conductivity of soil, without specifying the water content, density, temperature and composition, is meaningless. For a soil in place the composition and density are fixed, and the temperature typically varies over a small enough range to have only a small effect on thermal conductivity (unless the soil freezes). The main variable for a soil in place is therefore moisture content. The purpose of the thermal dryout curve is to represent the effect on thermal conductivity of this variability. This application note presents some of the methods which have been used to obtain thermal dryout curves, and recommends a simple method, combining two of them, which will give reliable results.

Options

Three methods have been used to obtain thermal dryout curves. The first is to model the curve using published relationships for soil thermal properties. The second is to monitor thermal conductivity and mass of a soil sample as it dries from saturation, and the third is to mix samples of a soil to water contents over a range and measure conductivity and water content on those samples.

1. *Modeling*: Campbell (1985) and Campbell et al. (1994) have published tested models describing thermal conductivity of soil as a function of water content, temperature, density and composition. For this method, a dryout curve is produced by determining the composition and density of the test sample and using the model to plot the dryout curve for the desired temperature. This method is very simple and straightforward, and requires very little information. Most users of the data, however, are more comfortable if there are some actual measurements of thermal conductivity on their samples to confirm that the calculations are correct. The model is useful, however, for investigating the effects of compaction, composition or temperature changes on the behavior of a soil or other thermal backfill material.

2. *Single sample:* For this method a soil sample, approximately 10 cm diameter and 10 cm deep, is prepared either by coring undisturbed soil or recompacting a soil sample to the desired density for the backfill material. The method for preparing the sample is determined by the use to be made of the dryout curve. The sample is saturated with water by placing it in a pan of water around 9 cm deep and allowing it to stand overnight. The Decagon TR1 thermal properties probe, or equivalent, is placed in the sample and a thermal conductivity reading is taken. The sample is then weighed. Over a period of time additional conductivity measurements and weightings are made as the sample dries. The sample finally is placed in a 105 C oven to fully dry it, and the final weighing and thermal conductivity measurements are made on the dry sample after it cools to room temperature. From the oven dry weight and a tare weight the water contents for all the other measurement times can be computed. The dryout curve is plotted from these data.

This method has the advantage of making all measurements on the same sample without disturbing it, so density stays constant unless the sample shrinks on drying. It has two big disadvantages, though. One is that it takes a long time to obtain the dryout curve. Soil doesn't dry very rapidly unless it is heated, and if it is heated, the high temperatures will strongly affect the conductivity measurements. Also, the thermal conductivity is measured at a point, approximately in the center of the sample. The weight measurement gives the average water content of the sample. Since soils, and other porous