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IEEE Guide for Thermal Resistivity Measurements of Soils and Backfill Materials

IEEE Power and Energy Society

Sponsored by the
Insulated Conductors Committee

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USA

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(Revision of IEEE Std 442-1981)

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Abstract: The measurement of thermal resistivity of soil and backfill materials to include concrete, engineered backfills, grout, rock, sand, and any other material used to encase the cable system installed in the ground is covered in this guide. A thorough knowledge of the thermal properties of a soil or backfill material enables the user to properly design, rate, and load underground cables. The method used is based on the theory that the rate of temperature rise of a line heat source is dependent upon the thermal constants of the medium in which it is placed. The designs for both laboratory and field thermal probes are also described in this guide.

Keywords: backfill, IEEE 442™, soil, soil thermal properties, thermal needle, thermal probe, thermal property analyzer, thermal resistivity

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Introduction

This introduction is not part of IEEE Std 442-2017, IEEE Guide for Thermal Resistivity Measurements of Soils and Backfill Materials.

An important design consideration in the design of underground cable systems is to understand the thermal resistivity characteristics of the materials that surround the cable. Over the years, many utilities, consultants, and testing firms have measured soil thermal resistivity both in situ and in the laboratory on selected soil samples. Such measurements have utilized various types of equipment and measurement techniques. In many cases, these testing methods have yielded inaccurate or inconsistent measurements of soil thermal resistivity. The Insulated Conductors Committee, recognizing the need for industry guidelines for the measurement of soil thermal resistivity, has prepared this guide to provide the user information on the test equipment that should be used to perform these material resistivity measurements. In addition, the guide provides information on how to make the in-situ or laboratory resistivity measurements and interpret the data in order to provide meaningful results using this equipment. The in-situ resistivity of a soil changes from season to season, due to changes in the moisture content of the soil or due to the relocation of the water table. It is important to consider these factors when determining a soil thermal resistivity value for ampacity calculations and rating underground cables.

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IEEE Guide for Thermal Resistivity Measurements of Soils and Backfill Materials

1. Overview

1.1 Scope

This guide covers the measurement of thermal resistivity of soil and backfill materials to include concrete, engineered backfills, grout, rock, sand, and any other material used to encase the cable system installed in the ground. A thorough knowledge of the thermal properties of a soil or backfill material enables the user to properly design, thermally rate, and load underground cables. The method is based on the theory that the rate of temperature rise of a line heat source embedded in the soil is dependent upon the thermal constants, including the thermal resistivity, of the medium in which it is placed. The designs for both laboratory and field thermal probes are also described in this guide.

1.2 Purpose

The purpose of this guide is to provide sufficient information to enable the user to select useful commercial test equipment, or to manufacture equipment that is not readily available on the market, and to make meaningful resistivity measurements with this equipment. Measurements may be made in the field or in the laboratory on recompacted soil samples or both.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ASTM D75, Standard Practice for Sampling Aggregates.

ASTM D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3(600 kN-m/m^3).[1]

ASTM D1452, Standard Practice for Soil Exploration and Sampling by Auger Borings.

[1]ASTM publications are available from the American Society for Testing and Materials (http://www.astm.org/).