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Standard Guide for Using the Frequency Domain Electromagnetic Method for Subsurface Site Characterizations¹

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1. Scope*

1.1 Purpose and Application:

1.1.1 This guide summarizes the equipment, field procedures, and interpretation methods for the assessment of subsurface conditions using the frequency domain electromagnetic (FDEM) method.

1.1.2 FDEM measurements as described in this standard guide are applicable to mapping subsurface conditions for geologic, geotechnical, hydrologic, environmental, agricultural, archaeological and forensic site characterizations as well as mineral exploration.

1.1.3 The FDEM method is sometimes used to map such diverse geologic conditions as depth to bedrock, fractures and fault zones, voids and sinkholes, soil and rock properties, and saline intrusion as well as man-induced environmental conditions including buried drums, underground storage tanks (USTs), landfill boundaries and conductive groundwater contamination.

1.1.4 The FDEM method utilizes the secondary magnetic field induced in the earth by a time-varying primary magnetic field to explore the subsurface. It measures the amplitude and phase of the induced field at various frequencies. FDEM instruments typically measure two components of the secondary magnetic field: a component in-phase with the primary field and a component 90° out-of-phase (quadrature component) with the primary field (Kearey and Brook 1991). Generally, the in-phase response is more sensitive to metallic items (either above or below the ground surface) while the quadrature response is more sensitive to geologic variations in the subsurface. However, both components are, to some degree, affected by both metallic and geologic features. FDEM measurements therefore are dependent on the electrical properties of the subsurface soil and rock or buried man-made objects as well as the orientation of any subsurface geological features or man-made objects. In many cases, the FDEM measurements

can be used to identify the subsurface structure or object. This method is used only when it is expected that the subsurface soil or rock, man-made materials or geologic structure can be characterized by differences in electrical conductivity.

1.1.5 The FDEM method may be used instead of the Direct Current Resistivity method (Guide D6431) when surface soils are excessively insulating (for example, dry or frozen) or a layer of asphalt or plastic or other logistical constraints prevent electrode to soil contact.

1.2 Limitations:

1.2.1 This standard guide provides an overview of the FDEM method using coplanar coils at or near ground level and has been referred to by other names including Slingram, HLEM (horizontal loop electromagnetic) and Ground Conductivity methods. This guide does not address the details of the electromagnetic theory, field procedures or interpretation of the data. References are included that cover these aspects in greater detail and are considered an essential part of this guide (Grant and West, 1965; Wait, 1982; Kearey and Brook, 1991; Milsom, 1996; Ward, 1990). It is recommended that the user of the FDEM method review the relevant material pertaining to their particular application. ASTM standards that should also be consulted include Guide D420, Terminology D653, Guide D5730, Guide D5753, Practice D6235, Guide D6429, and Guide D6431.

1.2.2 This guide is limited to frequency domain instruments using a coplanar orientation of the transmitting and receiving coils in either the horizontal dipole (HD) mode with coils vertical, or the vertical dipole (VD) mode with coils horizontal (Fig. 2). It does not include coaxial or asymmetrical coil orientations, which are sometimes used for special applications (Grant and West 1965).

1.2.3 This guide is limited to the use of frequency domain instruments in which the ratio of the induced secondary magnetic field to the primary magnetic field is directly proportional to the ground's bulk or apparent conductivity (see 5.1.4). Instruments that give a direct measurement of the apparent ground conductivity are commonly referred to as Ground Conductivity Meters (GCMs) that are designed to operate within the "low induction number approximation." Multi-frequency instruments operating within and outside the low induction number approximation provide the ratio of the

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*A Summary of Changes section appears at the end of this standard