Designation: D7046 – 11

Standard Guide for
Use of the Metal Detection Method for Subsurface Exploration[1]

1. Scope*

1.1 *Purpose and Application*—This guide summarizes the equipment, field procedures, and interpretation methods for the assessment of subsurface materials using the metal detection method. Metal detectors respond to the presence of both ferrous and nonferrous metals by inducing eddy currents in conductive objects. Metal detectors are either frequency domain (continuous frequency or wave) or time domain (pulsed) systems. A wide range of metal detectors is commonly available.

1.1.1 Metal detectors can detect any kind of metallic material, including both ferrous metals such as iron and steel, and non-ferrous metals such as aluminum and copper. In contrast, magnetometers only detect ferrous metals.

1.1.2 Metal detector measurements can be used to detect the presence of buried metal trash, drums (Tyagi et al, 1983) (**1**)[2] and tanks, abandoned wells (Guide D6285); to trace buried utilities; and to delineate the boundaries of landfill metal and trench metal. They are also used to detect metal based unexploded ordnance (UXO).

1.2 *Limitations:*

1.2.1 This guide provides an overview of the metal detection method. This guide does not provide or address the details of the theory, field procedures, or interpretation of the data. References are included for that purpose and are considered an essential part of this guide. It is recommended that the user of this guide be familiar with the references cited and with the ASTM standards D420, D653, D5088, D5608, D5730, D5753, D6235, D6429, and D6431.

1.2.2 This guide is limited to metal detection measurements made on land. The metal detection method can be adapted for a number of special uses on land, water, airborne and ice.

1.2.3 The approaches suggested in this guide for the metal detection method are commonly used, widely accepted, and proven. However, other approaches or modifications to the metal detection method that are technically sound may be substituted.

1.2.4 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.3 The values stated in SI units are regarded as standard. The values given in parentheses are inch-pound units, which are provided for information only and are not considered standard.

1.4 *Precautions:*

1.4.1 *It is the responsibility of the user of this guide to follow any precautions in the equipment manufacturer's recommendations and to establish appropriate health and safety practices.*

1.4.2 *If the method is used at sites with hazardous materials, operations, or equipment, it is the responsibility of the user of this guide to establish appropriate safety and health practices and to determine the applicability of any regulations prior to use.*

1.4.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

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[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.01 on Surface and Subsurface Characterization.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

D420 Guide to Site Characterization for Engineering Design and Construction Purposes (Withdrawn 2011)[4]
D653 Terminology Relating to Soil, Rock, and Contained Fluids
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5608 Practices for Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites
D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[4]
D5753 Guide for Planning and Conducting Borehole Geophysical Logging
D6235 Practice for Expedited Site Characterization of Vadose Zone and Groundwater Contamination at Hazardous Waste Contaminated Sites
D6285 Guide for Locating Abandoned Wells
D6429 Guide for Selecting Surface Geophysical Methods
D6431 Guide for Using the Direct Current Resistivity Method for Subsurface Investigation
D6639 Guide for Using the Frequency Domain Electromagnetic Method for Subsurface Investigations
D6820 Guide for Use of the Time Domain Electromagnetic Method for Subsurface Investigation

3. Terminology

3.1 *Definitions*—See Terminology D653.

3.2 The majority of the technical terms used in this document are defined in Sheriff (1991) (**2**), and Bates and Jackson (1997) (**3**).

4. Summary of Guide

4.1 *Summary of the Method*—A metal detector uses either a pulsed or an alternating current in a transmit coil to generate a time varying magnetic field around the coil. This primary magnetic field induces eddy currents in buried metal which in turn, induces a voltage in a receiver coil, which, when amplified, reveal the presence of buried metal. Benson (1982) (**4**) and U.S. EPA (1993) (**5**) provide an overview of metal detectors.

4.2 *Complementary Data*—Data from other surface geophysical methods (see Guide D6429) such as electromagnetics (Guides D6639 and D6820) and ground penetrating radar (Guide D6432) may be useful in fully evaluating buried metal response. Geologic data obtained from other complementary geological or surface geophysical methods (Guide D6429) and borehole geophysical methods (Guide D5753) may be necessary to help interpret and assess subsurface conditions.

5. Significance and Use

5.1 *Concepts:*

5.1.1 This guide summarizes the equipment, field procedures, and interpretation methods for using the metal detection method for locating subsurface metallic objects. Personnel requirements are as discussed in Practice D3740.

5.1.2 *Method*—Metal detectors are electromagnetic instruments that work on the principle of induction, using typically two coils (antennas); a transmitter and a receiver. Both coils are fixed in respect to each other and are used near the surface of the earth. Either an alternating or a pulsed voltage is applied to the transmitter coil causing electrical eddy currents to be induced in the earth. The electrical currents flowing in the earth are proportional to electrical conductivity of the medium. Theses currents generate eddy currents in buried metallic objects that is detected and measured by the receiver (Fig. 1).

5.2 *Parameter Measured and Representative Values:*

5.2.1 *Frequency Domain Metal Detectors:*

5.2.1.1 Frequency domain metal detectors apply an alternating current having a fixed frequency and amplitude to the transmit coil which generates a time-varying magnetic field around the coil. This field induces eddy currents in nearby metallic objects that in turn generate time-varying magnetic fields of their own. These eddy-fields induce a voltage in the receiver coil. The presence of metal causes small changes in the phase and amplitude of the receiver voltage. Most metal detectors amplify the differences in the receiver coil voltage caused by nearby metal and generate an audible sound or meter (analog or digital) reading.

5.2.1.2 Ground conductivity meters (frequency domain metal detectors) measure the two-components of the secondary magnetic field simultaneously. The first is the quadrature-phase component which indicates soil electrical conductivity and is measured in millisiemens per meter (mS/m). The second is the inphase component, which is related to the subsurface magnetic susceptibility and is measured in parts per thousand (ppt) (that is, the ratio between the primary and secondary magnetic fields).

(1) Conductivity Measurements (Quadrature-Phase Component)—Metallic objects within a few feet of the surface will cause induced magnetic field distortions that will result in zero or even negative values of measured conductivity. Deeper metallic objects will cause less field distortion and lead to measured conductivities which are abnormally high in comparison to site background values.

(2) Inphase Component—Inphase measurements are more sensitive to metal than conductivity measurements. Thus, inphase anomalies may indicate the presence of metal at a greater depth than the conductivity measurements.

5.2.2 *Time Domain Metal Detectors :*

5.2.2.1 In time domain metal detectors, a transmitter generates a pulsed primary magnetic field in the earth. After each pulse, secondary magnetic fields are induced briefly from moderately conductive earth, and for a longer time from metallic targets. Between each pulse, the metal detector waits until the response from the conductive earth dissipates, and then measures the prolonged buried metal response. This response is measured in millivolts (mV).

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[4] The last approved version of this historical standard is referenced on www.astm.org.

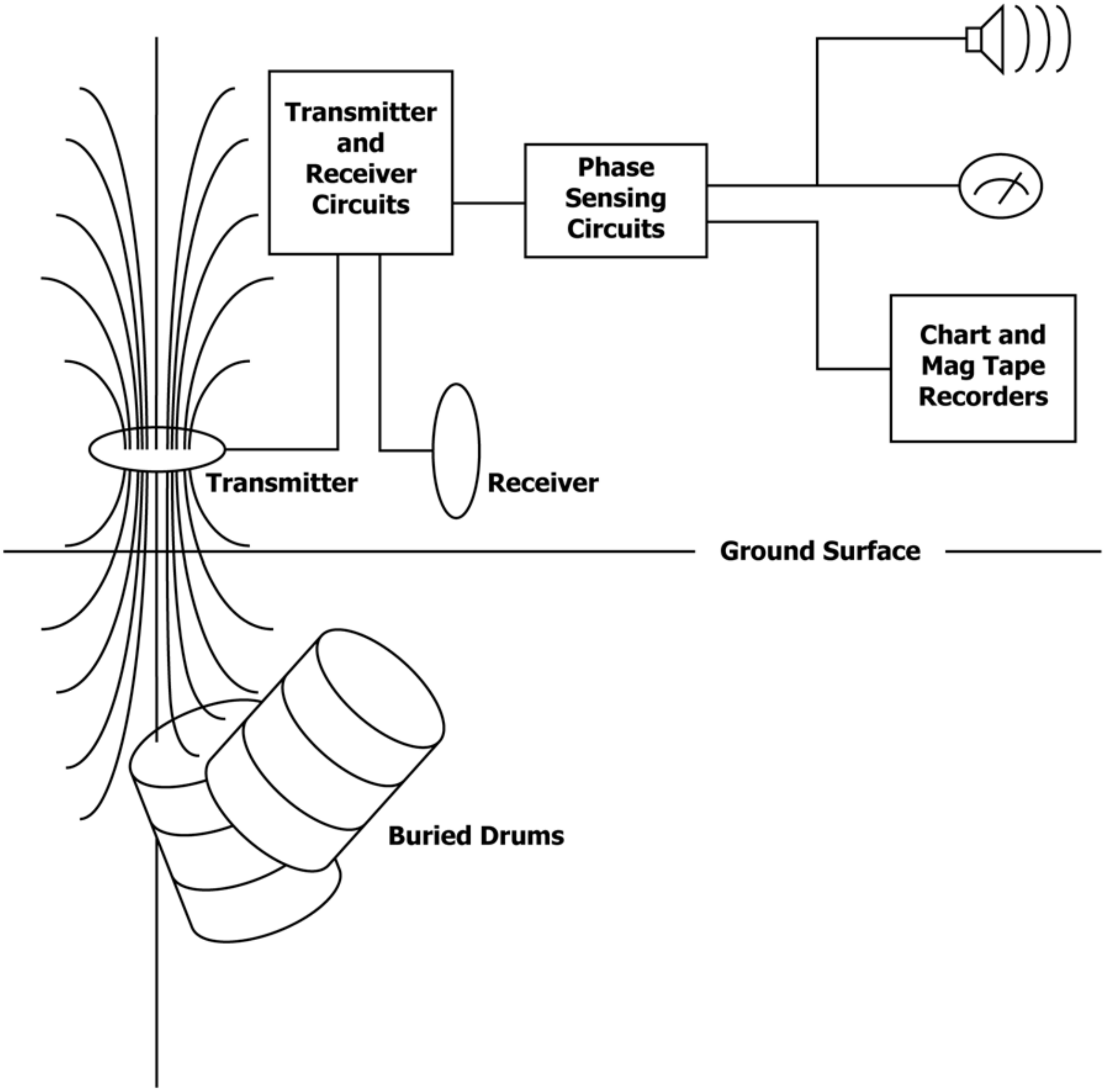


FIG. 1 Simplified Block Diagram of a Metal Detector System (Tyagi et al, 1983) (1)

5.3 *Equipment*—Metal detectors generally consist of transmitter electronics and transmitter coil, power supply, receiver electronics and receiver coil. Metal detectors are usually single individual portable.

5.3.1 Typical "treasure-hunter" metal detectors provide an audible signal and/or meter reading (analog or digital) when metal is detected.

5.3.2 Quadrature and inphase measurements from ground conductivity meters are shown either on analog or digital meters. These measurements can often be recorded digitally in the field using a small field recorder, strip-chart recorder, or computer.

5.3.3 Time domain metal detectors can consist of either one or two receiver coils. When two coils are used, one coil is typically placed above the other. Readings from both coils are recorded simultaneously. In order to improve detection of deeper metallic targets, the differential response from the two receiver coils can be used to suppress the response from smaller, shallower metallic targets. Some time domain metal detectors are mounted on wheels, allowing for the use of odometers to provide location data.

5.4 *Limitations and Interferences :*

5.4.1 *General Limitations Inherent to Geophysical Methods:*

5.4.1.1 A fundamental limitation of all geophysical methods is that a given set of data cannot be associated with a unique set of subsurface conditions. In most situations, surface geophysical measurements alone cannot resolve all ambiguities, and some additional information, such as borehole data, is advised. Because of this inherent limitation in the geophysical methods, a metal detector survey alone can never be considered a complete assessment of subsurface conditions. Properly integrated with other geologic information, metal detector surveying is a highly effective method of obtaining subsurface information.

5.4.1.2 In addition, all surface geophysical methods are inherently limited by decreasing resolution with depth.

5.4.2 *Limitations Specific to the Metal Detection Method:*

5.4.2.1 Several factors influence metal detector response: the properties of the target, the properties of the soil/rock, and the characteristics of the metal detector itself. The target's size, depth, and condition of burial are the three most important factors.

5.4.2.2 The larger the surface area of the target, the greater the eddy current that may be induced, and the greater the depth at which the target may be detected.

5.4.2.3 The metal detector's response decreases at a rate equal to the reciprocal of its depth up to the sixth power ($1/\text{depth}^6$). Therefore, if the distance to the target is doubled, the metal detector response will decrease by a factor of 64. Consequently, the metal detector is a relatively shallow-depth device. It is generally restricted to detecting small objects at relatively shallow depths or larger targets at limited depths. Generally, most metal detectors are incapable of responding to targets at depths much greater than 6 m.

5.4.2.4 Although the shape, orientation, and composition of a target will influence the metal detector response, these factors will have much less influence than will the size and depth of the target. Target deterioration, however, has a significant impact. Metallic containers will corrode in natural soils conditions. If a container is corroded, its surface area will be significantly reduced, and in turn will degrade the response of a metal detector.

5.4.2.5 Because the metal detector's response weakens rapidly with increasing distance to the target, system gain and instrument stability are important. The size of the coil controls the size and depth of the metallic target that can be detected as shown in Fig. 2.

5.4.3 *Interferences Caused by Natural and Cultural Conditions:*

5.4.3.1 Sources of noise referred here do not include those of a physical nature such as difficult terrain or man-made obstructions but rather those of a geologic, ambient, or cultural nature that can adversely affect the measurements and hence the interpretation.

5.4.3.2 *Natural Sources of Noise*—Some kinds of soil/rock, particularly those containing high iron content (often known as mineralized soil) affect receiver coil output strongly enough to indicate the presence of a metal target with certain kinds of metal detectors. Some types of metal detectors provide a means for compensating the output for the ground effect. This usually requires the operator to position the detector near the ground (but not near a metal target) and adjust a control until the target signal disappears. Small variations in the soil characteristics and stones (particularly those containing metallic compounds) can cause small changes in the detector output. Often these changes cause small target-like signals, known as "ground noise." These can confuse the operator because they sound like small targets.

5.4.3.3 *Cultural Sources of Noise*—Cultural sources of noise can include interference from electrical power lines, communications equipment, nearby buildings, and metal fences. Interference from power lines is inversely proportional to the distance between power line and detector; therefore most metal detectors with small coils are generally unaffected.

5.4.3.4 Surveys should not be made in close proximity to buildings, metal fences or buried metal pipe lines that can be detected by the metal detection method, unless detection of the buried pipe line, for example, is the object of the survey. It is sometimes difficult to predict the appropriate distance from the potential sources of noise. Measurements made on-site can quickly yield the magnitude of the problem, and adjustments can then be made.

5.4.3.5 Precaution must also be taken to remove metal from the operator, or to minimize its effects. Steel-toe boots, respirators, and air bottles can all cause considerable problems with noise.

5.5 *Summary*—During the course of designing and carrying out a metal detection survey, the sources of ambient, geologic and cultural noise must be considered and the time of occurrence and location noted. The exact form of the interference is not always predictable, as it not only depends upon the type of noise and the magnitude of the noise but also upon the distance from the source of noise and possibly the time of day.

5.6 *Alternate Methods*—In some cases, the factors discussed above may prevent the effective use of the metal detection method, and other surface geophysical methods (see Guide D6429) such as electromagnetics (Guides D6639 and D6820) or ground penetrating radar (Guide D6432) or non-geophysical methods may be advised to investigate subsurface conditions.

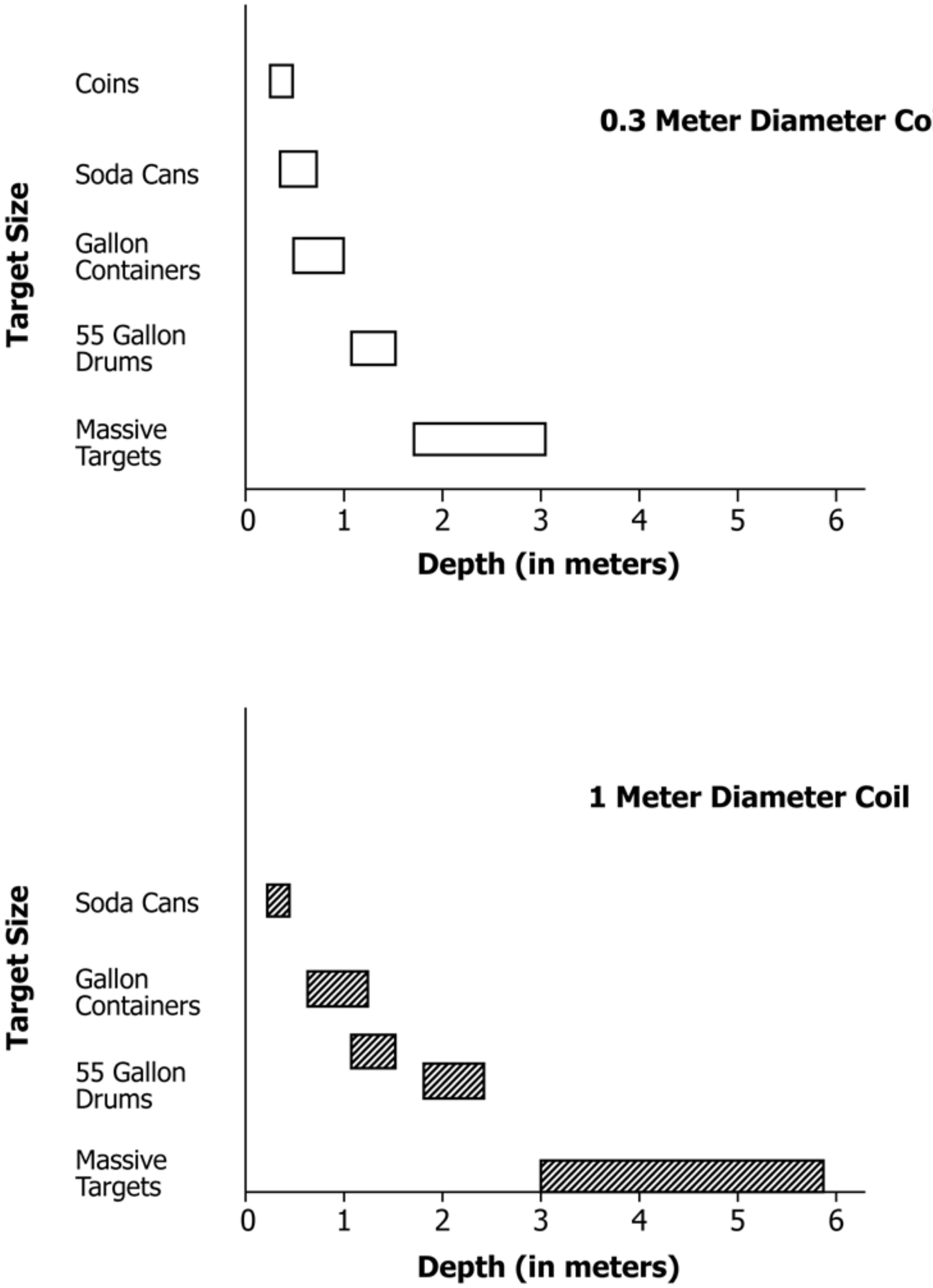
6. Procedure

6.1 This section includes a discussion of personnel qualification, considerations for planning and implementing the metal detection survey, and interpretation of the data.

6.1.1 *Qualification of Personnel*—Success of a metal detection survey, as with most geophysical techniques, is dependent upon many factors. One of the most important factors is the competence of the person(s) responsible for planning, carrying out the survey, and interpreting the data. An understanding of the theory, field procedures, and methods for interpretation of metal detection data along with an understanding of the site geology is necessary to successfully complete a survey. Personnel not having specialized training or experience should be cautious about using this technique and solicit assistance from qualified practitioners.

6.2 *Planning the Survey*—Successful use of the surface metal detection method depends to a great extent on careful and detailed planning as discussed in this section.

6.2.1 *Objectives of the Metal Detection Survey*—Planning and design of a metal detection survey should be done with due consideration to the objectives of the survey and the characteristics of the site. These factors will determine the survey design, the equipment used, the level of effort, the interpretation method selected, and the budget necessary to achieve the desired results. Important considerations include site geology, desired depth of investigation, topography, and access. The presence of noise-generating activities and operational constraints (which may restrict survey activities) must also be considered. It is good practice to obtain as much of the relevant information as possible about the site prior to designing a survey and mobilization to the field. For example, data from



NOTE 1—Data are shown for two metal detector coil sizes.

FIG. 2 Approximate Detection Ranges for Common Targets (Tyagi et al, 1983) (1)

any previous metal detection work, other surface geophysical methods, boreholes, geologic and geophysical logs in the study area along with topographic maps or aerial photos should be used to plan the survey.

6.3 *Survey Design*—The main consideration affecting the survey design is the survey objective, which will generally determine the type of metal detector, the survey pattern, station density, and the type and number of measurements needed.

6.3.1 There must be a clear technical objective to the metal detection survey. Target size, depth, and orientation, should be estimated, as well as number and distribution of targets. It is extremely important that the length of a profile line or area of survey should be larger than the area of interest so that sufficient measurements are taken in background conditions to establish that any detected anomaly is indeed anomalous.

6.3.2 *Instrument Selection*—The instrument selected will primarily depend on the depth of exploration required, type of data needed (qualitative or quantitative), and the survey objectives. This may mean selecting more than one metal detector to fulfill the project requirements.

6.3.3 *Survey Geometry*—Metal detection data may be obtained randomly (for reconnaissance surveys), along a single profile line, narrow or widely spaced profile lines, or over a uniform grid. The station spacing will be determined by the resolution required. Efforts should be made, if appropriate, to avoid biasing the data by taking many more measurements in one direction than in another. The distance between station measurements should be close enough to define the expected anomaly. An anomaly must be defined by a minimum of 3 points and preferably by more points.

6.3.4 Preliminary locations of survey lines are usually selected with the aid of topographic maps, aerial photos, and site maps showing cultural interferences, such as buildings, fences, and power lines. Primary consideration to the location and density of survey lines should be determined by the objectives of the survey.

6.3.5 In all cases, the survey line or areal coverage should extend sufficiently beyond the target area to give good reference to the normal background conditions.

6.4 *Survey Implementation:*

6.4.1 *On Site Check of Survey Plan*—A systematic visual inspection of the site should be made upon arrival to determine if the initial survey plan is reasonable. At this point, modifications to the survey plan may be necessary.

6.4.2 *Feasibility Test*—Initial measurements should be made to assess the noise conditions at the site. Results of the initial measurements may require that changes be made to the original survey plan.

6.4.3 *Lay Out Survey Lines*—Locate the best position for the metal detector survey lines based on the survey design described in 6.3 and the on-site conditions.

6.4.3.1 For qualitative surveys, mark the location of metallic anomalies on the ground and on a site map. For quantitative surveys, mark station locations on the ground and on a site map or, if continuous measurements are being recorded, mark stations for fiducial markings. The fiducial marks will help to reduce the measurements to spatially oriented measurements with a minimum of error. Variations in walking or vehicle speed will result in positioning errors, which are corrected for each time a fiducial mark is recorded. The closer the fiducial marks, the smaller the spatial error.

6.4.3.2 A Differential Global Positioning System (DGPS) can be used to locate the position of each target or measurement within the error specified for the DGPS.

6.5 *Interpretation:*

6.5.1 The level of effort involved in the interpretation depends upon the objectives of the survey, the type of instrument used, and the detail desired.

6.5.1.1 A problem inherent in all geophysical studies is the nonunique correlation between possible subsurface models and a single set of field data. This ambiguity can only be resolved through the use of geologic, geophysical, and other available information along with the experience of the interpreter.

6.5.1.2 Any preliminary interpretation should be treated with caution. Preliminary analysis done in the field is mostly a means of quality control.

6.5.2 *Qualitative Surveys:*

6.5.2.1 Most frequency domain metal detectors have both audio and meter indicators, with no provision for directly recording the information output. Reconnaissance-level surveys with relatively simple site conditions can be handled effectively with these instruments.

6.5.2.2 Metal detector responses or target locations can be noted in a field log, or on a site map. Stakes or paint marks can be placed over target centers or around their boundaries as the survey proceeds. These types of metal detector results are generally self-evident, and further analysis and processing are unnecessary.

6.5.3 *Quantitative Surveys:*

6.5.3.1 The output from some frequency domain metal detectors and most time domain metal detectors can be digitally recorded in the field. Some older instruments use strip chart recorders or magnetic tape to record data in the field. Such recorded data is useful when site conditions are complex such as when mapping the boundaries of metal in randomly-oriented trenches and buried pits.

6.5.3.2 Data processing such as filtering can be applied to recorded data to remove high-frequency noise from small local targets.

6.5.3.3 Profiling with metal detectors is most often used for locating anomalies such as pipes, tanks, or trenches. These are generally detected by a measurement signature characteristic of the anomaly and can be interpreted by visually inspecting the plotted profile data.

6.5.3.4 Surveys taken in a grid fashion are usually intended to map the lateral extent of some feature such as a buried disposal site or a site with buried tanks and piping. They can also be high-resolution surveys looking for small buried objects such as in an archeological or forensic investigation. In either case, the data are plotted and contoured and interpreted visually by geometric patterns on signal contrasts. The interpreter applies his knowledge of the site, what he expects to find and what the target is expected to look like if detected.

6.5.3.5 *Estimation of Target Depth*—An approximation of target depth can be made with data from time domain metal detectors having a lower and upper receiver coil. The apparent depth approximation is most accurate when the instrument is positioned over the center of the buried target. The accuracy of the approximation will depend on the relation between the line (station) and center of the target, the size and shape of the target, as well as on the quality of the data.

6.6 *Quality Control (QC)*—Quality control can be appropriately applied to metal detection measurements and are applicable to the field procedures, processing and interpretation phases of the survey. Good quality control requires that standard procedures are followed, personnel are appropriately qualified, relevant site information is incorporated into the interpretation and appropriate documentation made. Success of a metal detection survey, as with most geophysical techniques, is dependent upon many factors. One of the most important factors is the competence of the person(s) responsible for planning, carrying out the survey, and interpreting the data. An understanding of the theory, field procedures, and methods for interpretation of metal detection data along with an understanding of the site geology is necessary to successfully complete a survey. Personnel not having specialized training or experience should be cautious about using this technique and solicit assistance from qualified practitioners.

6.6.1 *Calibration and Standardization*—In general, the manufacturer's recommendation should be followed for calibration and standardization. If no such recommendations are provided, a routine check of equipment should be made on a periodic basis and after each problem and repair. A operational check of equipment along with a test measurement made in a background or test area should be carried out before each project and before the start of a new project and before starting fieldwork each day.

6.6.2 *Survey Procedure*—The use of Differential Global Positioning Systems (DGPS) or accurate surveying systems can sometimes significantly improve the quality of the survey. DGPS are relatively easy to use and generally cost effective and they can provide survey locations that are operator independent. Any needed follow-up survey can then be simply and accurately located with respect to the original survey.

6.6.3 Field procedure QC should include:

6.6.3.1 Documentation of anomaly location, survey grid or station layout and measurements to be taken.

6.6.3.2 Documentation of any changes to the planned field procedure due to previously unknown site conditions (man-made and natural).

6.6.3.3 Any other conditions possibly affecting the survey and measurements including topography, obstacles, weather conditions, and nearest power lines should be recorded.

6.6.3.4 Profile or grid data should be plotted immediately after data acquisition to ensure that the data is of adequate quality and quantity to define survey objectives.

6.6.3.5 Documentation of any problem with the equipment; what steps were taken to correct the problem, and how the problem could affect the data.

6.6.3.6 Establish and revisit nearby base station background or test area on a periodic basis.

7. Quality Assurance

7.1 It is generally good practice to have the entire survey results, including the report, reviewed by a person knowledgeable with the TDEM/TEM method and the site geology, but not directly involved with the project.

8. Report

8.1 *Components of the Report:*

8.1.1 The following is a list of the key items that should be contained in most reports. In some cases there may be no need for an extensive formal report. A report that meets or follows an organization's specific requirements can be substituted as long as the following items are included.

8.1.2 The report should include a discussion of:

8.1.2.1 The purpose and scope of the survey,

8.1.2.2 The geologic setting,

8.1.2.3 Any limitations of the survey,

8.1.2.4 Any assumptions that were made,

8.1.2.5 The field approach used, including a description of the equipment and the data acquisition parameters used,

8.1.2.6 The location of metallic anomalies, or the location of survey line(s) or grid along with a site map,

8.1.2.7 Any corrections applied to field data, along with justification for their use,

8.1.2.8 The results of field measurements,

8.1.2.9 Copies of typical raw data and mechanism for obtaining all data,

8.1.2.10 The format of recorded data,

8.1.2.11 Copies of the processed profiles and/or contours,

8.1.2.12 The method of interpretation used and specifically what analytical method(s) or software program(s) were used,

8.1.2.13 The interpreted results along with any qualifications and alternate interpretations,

8.1.2.14 If conditions occurred where a variance from this guide is necessary, the reason for the variance should be given,

8.1.2.15 Appropriate supporting data or references used in the interpretation, and

8.1.2.16 Persons responsible for the survey and data interpretation.

9. Precision and Bias

9.1 *Precision*—Precision is the repeatability between measurements. If a metal detector measurement is repeated under identical conditions with low noise levels, the measurements would be expected to be within 2 to 3 %. Different data quality objectives may be set depending on the purposes of the survey and on site conditions.

9.2 *Bias*—For the purposes of this guide, bias is defined as a measure of the closeness to the truth.

9.2.1 Some of the factors that affect bias are:

9.2.1.1 Errors in field procedures, record-keeping, corrections to data, processing and interpretation,

9.2.1.2 Instrument errors in measuring or recording,

9.2.1.3 Geometry limitations, relating to line location and topography,

9.2.1.4 Variation of the earth from simplifying assumptions used in the field and interpretation procedure,

9.2.1.5 Site-specific geologic limitations, such as ambient radiated or induced noise, or the presence of buried conductors,

9.2.1.6 Ability and experience of the field crew, data processor and interpreter, and

9.2.1.7 Operator bias for small anomalies at or near the noise level of the equipment and setting, particularly on data sets that are not digitally recorded.

9.3 *Resolution:*

9.3.1 *Lateral Resolution*—Lateral resolution for the metal detector method is primarily dependent on the coil geometry, target depth and size, and the measurement spacing. Instruments with smaller coils provide better resolution for a shallower depth. Resolution can be improved by decreasing the station separation. Decreasing the line spacing will always provide more information on target location and size.

9.3.2 *Vertical Resolution*—Vertical resolution for the metal detector method is defined as how small a change in depth can be detected. In general, the most that can be expected from the metal detector method is an approximation. The accuracy of the approximation will depend on the relation between the line (station) and center of the target, the size and shape of the target, as well as on the quality of the data.

10. Keywords

10.1 frequency domain; geophysics; metal detection; metal detector; subsurface investigation; surface geophysics; time domain

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this guide since the last issue, D7046–04, that may impact the use of this guide. (Approved May 1, 2011)

(*1*) Moved description of metal detector types from Scope to Significance and Use.
(*2*) Moved Personnel Qualifications from Procedure to Quality Control.
(*3*) Moved method citations from Scope to Procedure.
(*4*) Changed title from "Investigation" to "Exploration."
(*5*) Replaced professional judgment caveat with correct language.

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