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Standardized Testing of Metal Detectors

Stemming from initiatives to promote standardization within humanitarian mine action, a workshop has been established to standardize the testing of metal detectors. This has produced a CEN Workshop Agreement that gives principles, guidelines and procedures for detector testing.

by T.J. Bloodworth and A.J. Sieber, EC JRC

Introduction

Metal detectors are an essential part of the toolkit of a humanitarian deminer. In recent years, demining end-users have required testing and evaluation of the available metal detectors prior to making procurement decisions. Many trials of the capabilities of metal detectors have been performed. However, the lack of an agreed standard for testing these instruments has limited the value of this work to the end-users. It is difficult to make cross-comparison between instruments to determine which is best-suited to any particular need.

In response to this problem, CEN Workshop 7, "Humanitarian Mine Action — Test and Evaluation — Metal Detectors" (CW07) was established. CW07 has the objective of developing specifications for the testing and evaluation of metal detectors used in humanitarian mine clearance. The background to CW07 is presented here, as well as a summary of the tests that have been specified.

History of CW07

Following a mandate given to the European Center for Standardization (CEN) by the European Commission, the Working Group CEN BT/7WG 126 was set up with the aim of making recommendations and initiating standardization within humanitarian mine action. One of the first decisions of CEN BT/7WG 126 was that a CEN Workshop be started in order to standardize the testing and evaluation of metal detectors. It was proposed that the European Commission Joint Research Centre (JRC) be the "driving force" of this process. One great advantage of a CEN Workshop is that it is open to all, not restricted to those from CEN member states.

In addition, the International Test and Evaluation Program for Humanitarian Demining (ITEP) gave its support to the idea of standardization of metal detector test and evaluation and requested that the JRC initiate the CEN Workshop. Support has also been given by the United Nations Mine Action Service (UNMAS) and by the Geneva International Centre for Humanitarian Demining (GICHD), which is responsible for International Mine Action Standards (IMAS). Close cooperation has been maintained with the GICHD.

CW07 was launched on 8 November 2001 in Brussels, with the approval of the Business Plan. It was agreed that JRC provide both the Chairmanship and the Secretariat, with standardization support from CEN via UNMAS and the Italian CEN member states. The aim of CW07 was to produce a CEN Workshop Agreement (CWA) giving principles, guidelines and testing procedures for the testing and evaluation of metal detectors.

Full meetings of the Workshop took place at JRC, Ipira, Italy, in December 2001, April 2002 and December 2002 at which the decisions were made about the tests that should be performed, how they should be done and how the specifications should be written in the CWA. Between the April and December 2002 meetings, a small Drafting Working Group met twice at Defense Research and Development Canada (DRDC), Suffield, in June 2002 and in Ipira in September 2002 to make further progress in producing the CWA.

Following the full meeting of CW07 in December 2002, a final version of the CWA was prepared. The final version was submitted to CEN in May 2003 for approval and publication. The Agreement is issued by CEN as CWA 14747:2003.

Experience Applied in CW07

In formulating the standardized test procedures for the CWA, extensive use has been made of the test procedures developed and followed during the International Pilot Project for Technology Co-operation (IPPTC) for commercial off-the-shelf (COTS) metal detectors. Previous standardization work on denuding testing has also been useful in the preparation of the CWA, for example the International Test Operations Procedures (ITOPs), and studies of metal detector responses and tests used in previous metal detector trials have given valuable information.

In addition, an existing U.S. military Performance Specification (MPS) for metal detectors and a standard for metal detectors used for detection of concealed weapons and contraband in the U.S. penal system was also considered in CW07. The most important contribution was the combined experience of the members of CW07 that was brought to the Workshop. Manufacturers, testing laboratories, researchers into metal detection and those with experience of using and testing detectors in the field all contributed to creating the test specifications.

General Principles of CWA 14747

CWA 14747 establishes the general principles of testing and the most important of these is that all of the tests of detection capability are based on the idea that the only output that the detector gives is a yes/no alarm signal. This means that all of the testing is based upon a correct alarm/no alarm judgment. For some detectors this is clear for others, less so. A criterion is therefore defined; detection has occurred when a repeatable, non-intermittent alarm indication is produced.

To quantify detection capability, the maximum detection height or depth of a target is used. The distance is always measured from the top of the target concerned. When testing in air, the height of the sensor from the top of the target is measured. In soil, the depth of the top of the target below soil level and the sweep height of the sensor above the soil are measured. Figure 1 shows this convention schematically.

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Operational Performance Tests

As well as the many tests focusing on the detection capability, specifications are given for tests of location accuracy, the ability to characterize target shape and the capability to resolve adjacent targets. Tests to remove the effect of specific soils and other media encountered in the field are given.

One aspect of metal detector performance that is of particular importance is the ability to operate near to a large, near metal structure such as a rail. A test is included to measure the minimum operating distance in this situation.

Specific tests to determine whether particular interference sources affect a detector, or to what extent detectors interfere with one another are given.

Ergonomic and Operational Aspects

Although the major part of the CWA is taken up with measurements of the detection performance, in one way or another, part of the document is devoted to other aspects of the evaluation of detectors that are important to users. Among these aspects is the robustness of the detector. Any equipment used in demining must be sufficiently robust to endure rough handling for many years of operation without breaking. The weight and balance of detectors are also important concerns; users want operators to be able to use them for long periods of time. Detectors need to be easy to use and the way that they should be used needs to be understandable to deminers. Guidelines are therefore given in CWA 14747 for the analysis of ergonomic and operational qualities of a detector.

Characterization of Soil

The electromagnetic properties of soils that affect metal detectors are the complex (frequency-dependent) magnetic susceptibility and (to a lesser extent) the electrical conductivity. Unfortunately, a simple scale of soil “noisiness” based on these properties is not yet established. Making strict comparisons between the metal detector test results obtained on different soils is therefore difficult.

However, guidelines have been produced that begin to create a classification of soils based on their properties.

Application of the CWA Tests

Different parts of CWA 14747 are intended to be used by R&D laboratory researchers, manufacturers, operators of test and evaluation facilities, organizations needing to procure metal detectors, Mine Action Centres (MACs) and metal detector operators in the field.

The order of the testing followed in the CWA follows a logic that begins with tests of the basic operating performance. These tests are in the root controlled conditions, for which targets are in air not soil. To achieve such controlled conditions requires equipment and facilities that are usually not available in field environments so many of these tests need to be performed by specialist laboratories. Analogues tests are however specified for less-controlled conditions. Tests the CWA describes tests on targets in soil—again as controlled as possible. Tests then follow that may be feasibly performed in the field with a minimum of equipment.

Few users of the document will wish to, or be able to, perform all of the tests specified. A user in the field under MAC control, for example, may perform the detection reliability test, some of the tests of operational performance characteristics and some of the basic in-air and in-soil sensitivity measurements. However, the value of testing is greatly increased if a laboratory has already performed controlled tests, for example to determine whether the sensitivity of the detector under test varies with operating temperature.

Users of the CWA, who wish to conduct a trial of various metal detectors using the tests specified may also wish to conduct a pre-trial assessment to exclude detectors at the beginning that clearly do not meet their requirements. Such a pre-trial assessment would include one or more of the tests specified in the CWA, with acceptance levels set by the users according to their own requirements. The basic in-air sensitivity measurement could be used, for example, as an acceptance level established for the maximum detection height.

In order to help different users get the maximum benefit from using the

Figure 4: Sensitivity profile of a metal detector at three different heights above a target.

Figure 5: The effect of soil on detection capability.

The work of CRW7 has stimulated research into some of the problems encountered. For example, the validity of using ferromagnetic metals as ‘‘backgrounder’’ steel balls as test targets, understanding the effect of soil and how best to characterise it, and deriving the best way to measure detection reliability without using huge numbers of targets.

Some of this work has influenced the content of CWA 14747/2003 and some is ongoing, but should provide evidence for future revisions.

Figure 6: Detection reliability test in progress, c/o C. Müller, BAM

CWA, a number of categories of testing have been established.

One of the International Mine Action Standards (IMAS 03.40) deals with the test and evaluation of mine action equipment. IMAS 03.40 defines two types of testing trial: a consumer report trial (in which equipment is tested against general requirements) and an acceptance trial (in which equipment is tested against specific—usually local—requirements).

Testing can be “open” in which the operators know the details of what and what the targets are that they are trying to detect, or “blind” when they do not. Tests can be designed to be “well-controlled” laboratory-type tests or “less-controlled” field-type tests. Tests can be designed so that a target is in air or in soil. All of the tests in the CWA are put into the above categories to help users of the document identify what is appropriate for them.

Plans for Future Work

The first version of CWA 14747 was issued in June 2003 and has been presented to UNMAS and the GICHD with a view to its being included, or at least referred to, within an IEDM system.

A project is planned to vet how well the specified tests work, as well as to publish the CWA. This would involve performing trials using the CWA. Feedback would then be obtained on what improvements could be made. CRW7 will then be reconvened to produce any possible revision to the CWA that may be required.

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*All graphics courtesy of the author.

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