



Performance Standard for Hand-Worn Metal Detectors Used in Safety and Security¹

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1. Scope

1.1 This standard applies to all hand-worn or glove-type metal detectors used to find metal contraband concealed or hidden on people or other objects with hand-accessible surfaces. Hand-worn metal detectors (HWMDs) are significantly different in design compared to the more common hand-held metal detector (HHMD). For example, the HWMD generates a much more localized magnetic field than does the HHMD and the useful field of the HWMD is normal to the plane of the hand whereas the useful field of the HHMD is multi-directional.

1.2 This standard describes minimally acceptable performance requirements, which includes metal object detection performance, safety (electrical, mechanical, fire), electromagnetic compatibility, environmental conditions and ranges, and mechanical durability. The requirements for metal detection performance are unique and, therefore, test methods for these parameters are provided, including the design of test objects. An agency or organization using this standard is encouraged to add their unique operationally-based requirements to those requirements listed in this minimally-acceptable performance standard.

1.3 This documentary standard describes the use of spherical test objects, instead of actual threat objects or exemplars of threat objects, to test the detection performance of hand-worn metal detectors. Spherical test objects are used because the detectability of spherical test objects is not orientation dependent, whereas this is not true for non-spherical test objects. This orientation-dependent detectability of non-spherical test objects may allow a HWMD to be incorrectly attributed a higher performance capability than that HWMD is capable of providing. To aid agencies wishing to add specific threat objects to their detection performance requirements, included in [Annex A1](#) is the analysis of the probability of detection for different orientations of agency-specific non-spherical threat objects.

1.4 *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 limitations prior to use.

2. Referenced Documents

2.1 ISO Standards:²

ISO 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories

ISO 10012:2003 Quality Assurance Requirements for Measuring Equipment

ISO 14117:2012 Active Implantable Medical Devices—Electromagnetic Compatibility—EMC Test Protocols for Implantable Cardiac Pacemakers, Implantable Cardioverter Defibrillators, and Cardiac Resynchronization Devices

ISO 14708–1:2000 Implants for Surgery—Active Implantable Medical Devices—Part 1: General Requirements for Safety, Marking, and for Information to be Provided by the Manufacturer

ISO 14708–2:2012 Implants for Surgery—Active Implantable Medical Devices—Part 2: Cardiac Pacemakers

ISO 14708–3:2008 Implants for Surgery—Active Implantable Medical Devices—Part 3: Implantable Devices

ISO 14708–4:2008 Implants for Surgery—Active Implantable Medical Devices—Part 4: Implantable Infusion Pumps

ISO 14708–5:2010 Implants for Surgery—Active Implantable Medical Devices—Part 5: Circulatory Support Devices

ISO 14708–6:2010 Implants for Surgery—Active Implantable Medical Devices—Part 6: Particular Requirements for Active Implantable Medical Devices Intended to Treat Tachyarrhythmia (Including Implantable Defibrillators)

2.2 IEC Standards:³

IEC 61010–1 Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use—Part 1: General Requirements

¹ This performance standard is under the jurisdiction of ASTM Committee F12 on Security Systems and Equipment and is the direct responsibility of Subcommittee F12.60 on Controlled Access Security, Search, and Screening Equipment.

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² Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

³ Available from International Electrotechnical Commission (IEC), 3, rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland, <http://www.iec.ch>.

IEC 61000–6–1 Electromagnetic Compatibility (EMC), Part 6: Generic Standards—Sections 1: Immunity for Residential, Commercial, and Light-Industrial Environments

IEC 61000–4–2 Electromagnetic Compatibility (EMC), Part 4: Testing and Measurement Techniques—Section 2: Electrostatics Discharge Immunity Test

IEC 61000–4–3 Electromagnetic Compatibility (EMC), Part 4: Testing and Measurement Techniques—Section 3: Radiated, Radiofrequency, Electromagnetic Field Immunity Test

IEC 61000–4–8 Electromagnetic Compatibility (EMC), Part 4: Testing and Measurement Techniques—Section 8: Power Frequency Magnetic Field Immunity Test

IEC 60601–1–2 Medical Electrical Equipment—Part 1–2: General Requirements for Basic Safety and Essential Performance—Collateral Standard: Electromagnetic Disturbances—Requirements and Tests

IEC 60529 2001–2 Degrees of Protection Provided by Enclosures (IP Code)

IEC 60068–2–27: 2008–2 Environmental Testing—Part 2–27: Tests—Test Ea and Guidance: Shock

CISPR 22 Information Technology Equipment—Ratio Disturbance Characteristics—Limits and Methods of Measurement, Class B, Radiated Disturbance

2.3 IEEE Standard⁴

IEEE C95.1 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

2.4 Military Standards:⁵

MIL-STD-810G Method 501.5 Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, Method 501.5, High Temperature

MIL-STD-810G Method 502.5 Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, Method 502.5, Low Temperature

MIL-STD-810G Method 507.5 Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, Method 507.5, Humidity

2.5 ANSI Standard:⁶

ANSI S1.4–1983 Specification for Sound Level Meters

2.6 CIE Standard:⁷

CIE S 014–1/E:2006 Colorimetry—Part 1: CIE Standard Colorimetric Observers

3. Terminology

3.1 Definitions:

3.1.1 *alarm*—an indication that informs the operator of an event, such as metal detection or a detector (HWMD) status change.

3.1.2 *body simulant*—a material engineered to simulate the average electrical conductivity and magnetic permeability of the human body; the average electrical conductivity is 0.8 ± 0.2 S/m and the average magnetic permeability is $1.26 \times 10^{-6} \pm 5 \times 10^{-7}$ H/m.

3.1.3 *detector*—the hand-worn metal detector (HWMD) that is worn on the hand and is used for finding metal objects concealed on a person or other object (see Figs. 1 and 2).

3.1.4 *detector axis*—an imaginary line passing through and perpendicular to the detector plane that is located within the detector plane such that the magnetic field around the detector axis has the maximum symmetry; the detector axis is labeled as the “z” axis; the location of the detector axis relative to the HWMD shape and geometry is specified by the manufacturer; the detector axis is the reference for positioning in the detection performance tests (see Fig. 1).

⁶ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁷ Available from U.S. National Committee of the CIE (International Commission on Illumination), C/o Alan Laird Lewis, 282 E. Riding, Carlisle, MA 01741, <http://www.cie-usnc.org>.

⁴ Available from Institute of Electrical and Electronics Engineers, Inc. (IEEE), 445 Hoes Ln., Piscataway, NJ 08854-4141, <http://www.ieee.org>.

⁵ Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, <http://www.access.gpo.gov>.

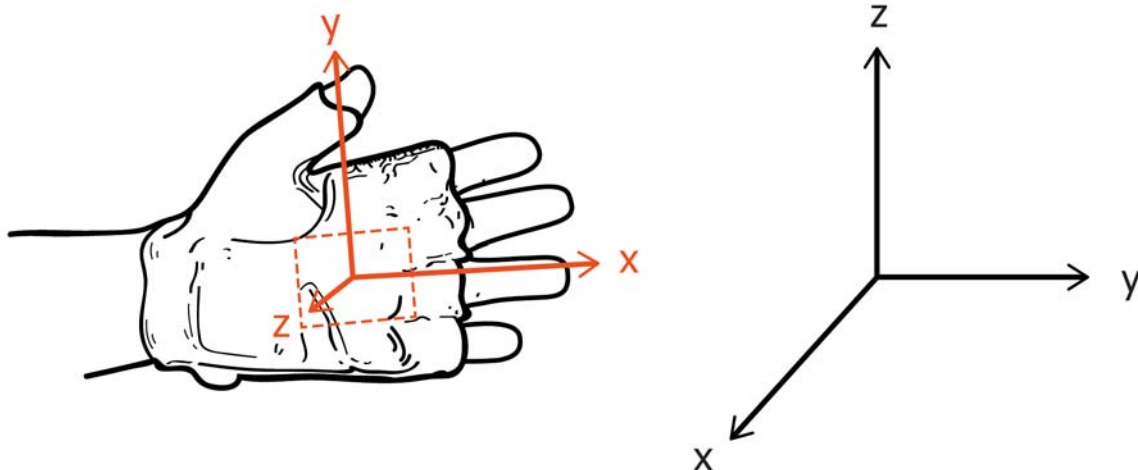
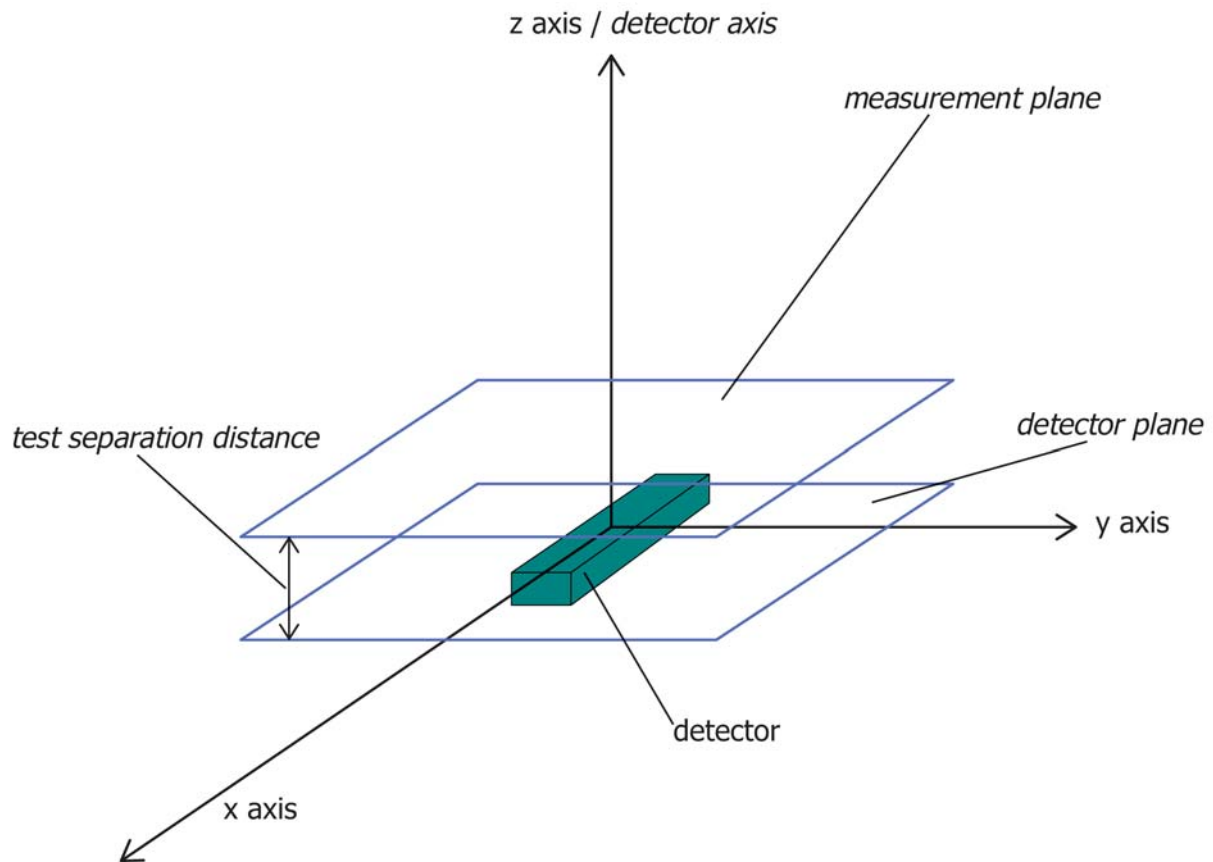


FIG. 1 Diagram of Hand-Worn Metal Detector Showing the Detector Plane (outlined in red) and the Detector Axis (labeled Z)



NOTE 1—The x-axis points along the user's arm.

FIG. 2 Diagram of the Measurement Coordinate System Showing the Measurement Coordinate System Axes, One Measurement Plane, and the Detector Plane

3.1.5 *detector holder*—a rectangular prism made of the body simulant on which the HWMD is worn.

3.1.6 *detector plane*—an imaginary plane (two-dimensional surface) that is tangential to the plane, line, or point on the HWMD surface that is closest to the object being scanned under typical HWMD use; the detector plane contains two orthogonal axes labeled as the “x” axis and as the “y” axis (see Fig. 2).

3.1.7 *detection sensitivity setting*—an adjustment that can be made to the HWMD that affects its ability to sense metal objects.

3.1.8 *measurement coordinate system*—a mutually orthogonal three-dimensional Cartesian coordinate system referenced to the detector axis and the detector plane; the three axes are labeled “x,” “y,” and “z,” where the z axis is parallel to the detector axis and the x axis and the y axis are in the detector plane (see Fig. 2).

3.1.9 *measurement plane*—an imaginary two-dimensional surface that is parallel to the detection plane and that is tangential to the plane, line, or point on the test object that is closest to the detection plane; there may be more than one measurement plane; the measurement plane(s) is (are) referenced from the detector plane (see Fig. 2); there is a measurement plane for each object-size class of the HWMD, as shown in Table 1.

TABLE 1 Distance Between Measurement Plane and Detector Plane for the Different HWMD Size Classes

Size Class	Distance Between Measurement Plane and Detector Plane (cm)
Large	1.5 -0/+0.25
Medium	1.0 -0/+0.25
Small	1.0 -0/+0.25
Very Small	0.5 -0/+0.25

3.1.10 *size class*—a classification method based on grouping exemplars of commonly encountered objects that may be either commercially available or readily fabricated from available materials and that are related to customer applications and object sizes; a HWMD may meet the requirements for one or all size classes, as defined below. For each size class, there are exemplars constructed of ferromagnetic metal and exemplars constructed of nonferromagnetic metal.

3.1.10.1 *large*—represents threat items such as handguns; and similarly sized objects, or larger.

3.1.10.2 *medium*—represents threat items such as knives having blade lengths exceeding 7.5 cm, and similarly sized objects, up to the size of a large object.

3.1.10.3 *small*—represents threat items such as, but not limited to, knives having blade lengths less than or equal to 7.5 cm, handcuff keys, handgun rounds, and similarly sized objects, up to the size of a medium object.

3.1.10.4 *very small*—represents threat items such as t razor blades, hypodermic needles and similarly sized objects, up to the size of a small object.

3.1.11 *test object*—an item that is used to test the HWMD detection performance; test objects accurately simulate the electromagnetic properties of an actual threat or contraband item, such as a weapon or an item that can be used to defeat security devices; the test objects are described in Section 6.

3.1.12 *test object axis*—the imaginary line passing through the center of the test object that is referenced to and has a one-to-one correspondence with the axes of the measurement coordinate system.

3.1.13 *x-axis scan range and y-axis scan range*—the segment of line along the x and y axis of the measurement coordinate system that is centered on the detector axis that extends equally on either side of the detector axis; the detection performance of the HWMD will be tested along both axes (see Table 2).

TABLE 2 X-axis and Y-axis Scan Ranges for the Different HWMD Size Classes

Size Class	X-axis and Y-axis Scan Ranges	
	lower limit (cm)	upper limit (cm)
Large	-3.0 ± 0.1	3.0 ± 0.1
Medium	-1.5 ± 0.1	1.5 ± 0.1
Small	-1.0 ± 0.1	1.0 ± 0.1
Very Small	-1.0 ± 0.1	1.0 ± 0.1

4. Requirements for Acceptance

NOTE 1—The HWMD shall meet or exceed the requirements and specifications stated in this section.

4.1 General Test Conditions and Requirements:

4.1.1 *Testing and Calibration Laboratories*—Laboratories performing testing and calibration of the HWMD or its components, or both, shall meet the requirements of ISO 17025, as amended.

4.1.2 *Measurement Equipment and Processes*—All measurement equipment and processes shall be certified to ISO 10012-1, as amended

4.2 Safety Specifications and Requirements:

4.2.1 *Electrical*—The HWMD shall comply with IEC 61010-1, Section 6, “Protection Against Electrical Shock,” as amended.

4.2.2 *Mechanical*—The HWMD shall meet requirements of IEC 61010-1, Section 10, “Equipment Temperature Limits and Resistance to Heat,” as amended.

4.2.3 *Thermal*—The HWMD shall meet the requirements of IEC 61010-1, Section 10, “Equipment Temperature Limits and Resistance to Heat,” as amended.

4.2.4 Human Exposure:

4.2.4.1 *General*—The magnitude of the electromagnetic field generated by the HWMD at a distance of approximately 5 mm from any surface of the HWMD shall be less than the

exposure limits specified for general public exposure in the ICNIRP Guideline⁸ and IEEE C95.1.

4.2.4.2 *Active Implanted and Body-worn Medical Devices*—The magnitude of the electromagnetic field generated by the HWMD shall not cause an active implanted or body-worn medical electronic device to be adversely affected as described in ISO 14117:2012, ISO 14708-1, ISO 14708-2, ISO 14708-3, ISO 14708-4, ISO 14708-5, ISO 14708-6, and IEC 60601-1-2 and tested in accordance with the same. If adherence to the requirement in 4.2.4.2 has not been demonstrated, the manufacturer shall provide a warning with the HWMD instructions that states, “This device has not been demonstrated as being safe for use on people with active implanted and/or body-worn medical devices.”

4.3 Power Requirement:

4.3.1 *Battery Life*—The HWMD shall operate for at least 8 h as tested in accordance with 5.4 and while using a battery of the type and model recommended by the manufacturer.

4.4 *Detection Performance Specifications*—The ability of the HWMD to sense the presence of a test object will vary with the material, type, and orientation of the test object. Consequently, the test objects are grouped according to their size class and the HWMDs are tested for their ability to detect test objects from within these different size classes. The detection performance specifications shall be tested using the detection sensitivity setting, if applicable, that is specified by the manufacturer to be appropriate for each test object size class. All the tests of 5.2 requirements shall be performed within an 8 ± 0.5 h period without adjusting the detector sensitivity setting between tests. The detector sensitivity setting shall not be readjusted during testing, or after changing the battery. The test objects are given in Section 6.

4.4.1 *Detection Sensitivity*—The HWMD shall exhibit an average probability of detection, $p_{d, \text{sens}} \geq 0.95$ with an average confidence level of 0.95 for the test objects in each size class, when each object in the size class is positioned in the appropriate measurement plane (see Table 1) over the appropriate x-axis scan range and y-axis scan range (see Table 2) with the test object moving at a speed of 0.5 ± 0.05 m/s and tested in accordance with 5.2.2. This requirement is met when $P_{LB} \geq p_{d, \text{sens}}$ as computed per 5.2.2.

4.4.2 *Detection Speed*—The HWMD shall exhibit an average probability of detection $p_{d, \text{sp-sens}} \geq 0.95$ with an average confidence level of 0.95 for the test objects in each size class, when each object in the size class is positioned in the appropriate measurement plane (see Table 1) over the appropriate x-axis scan range (see Table 2), with the test object moving at a speed of 0.2 ± 0.01 m/s, 0.5 ± 0.01 m/s, and 1.0 ± 0.01 m/s as tested in accordance with 5.2.3 under the following conditions: (1) The delay between subsequent tests of a given test object shall be no more than 5 ± 0.5 s; and (2)

⁸ ICNIRP, “Guidelines for Limiting Exposure to Time-varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz),” International Commission on Non-Ionizing radiation Protection (ICNIRP), Health Physics, April 1998, Volume 74, No. 4, pp. 494–522.