ASTM INTERNATIONAL

Designation: F3278 – 20

Standard Performance Specifications and Test Methods for Hand-Held Metal Detectors Used in Safety and Security[1]

1. Scope

1.1 This standard applies to all hand-held metal detectors (HHMDs) used to find metal contraband concealed or hidden on people or other objects with accessible surfaces. This standard describes baseline 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 baseline performance specification.

1.2 This 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-held 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 HHMD to be incorrectly attributed a higher performance capability than that HHMD is capable of providing. To aid agencies wishing to add specific threat objects to their detection performance requirements, included in Appendix X1 is the analysis of the probability of detection for different orientations of agency-specific threat objects.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]
F3356 Practice for Conformity Assessment of Metal Detectors Used in Safety and Security

2.2 *ISO Standards:*[3]
ISO 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories
ISO 10012:2003 Measurement Management Systems – Requirements for Measurement Processes and 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 14708-3:2017 Implants for Surgery – Active Implantable Medical Devices – Part 3: Implantable Neurostimulators
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)

ISO 14708-7:2013 Implants for Surgery – Active Implant-able Medical Devices – Part 7: Particular Requirements for Cochlear Implant Systems

2.3 *IEC Standards:*[4]

IEC 60529 2001-2 Degrees of Protection Provided by En-closures (IP Code)

IEC 60068-2-31:2008-05 Environmental Testing – Part 2:31: Tests – Test Ec: Rough Handling Shocks, Primarily for Equipment-type Specimens

2.4 *IEEE Standards:*[5]

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

IEEE C95.6 IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 kHz to 3 kHz

IEEE Std 181-2011 IEEE Standard for Transitions, Pulses, and Related Waveforms

2.5 *Military Standards:*[6]

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

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

2.6 *ANSI Standards:*[7]

ANSI S1.4-1983 Specification for Sound Level Meters

3. Terminology

3.1 *Definitions:*

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[4] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st Floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

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

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

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

3.1.1 *alarm*—an indication (which may be audible, visual, or vibratory, or combinations thereof) that informs the operator of an event, such as metal detection or a detector (HHMD) status change.

3.1.2 *detector*—the hand-held metal detector (HHMD) that is held in one hand and is used for finding metal objects concealed on a person or other object.

3.1.3 *detector axis*—an imaginary line passing through and perpendicular to 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 HHMD shape and geometry is specified by the manufacturer. The detector axis is the refer-ence for positioning in the detection performance tests. See Fig. 1.

3.1.4 *detector holder*—a device used to hold the HHMD in place during testing. The detector holder is constructed of non-ferromagnetic and non-electrically conductive materials.

3.1.5 *detector plane*—an imaginary plane (two-dimensional surface) that contains the plane, line, or point on the HHMD surface that is closest to the object being scanned under typical HHMD use and is perpendicular to the detector axis. The detector plane contains two orthogonal axes labeled as the "x" axis and as the "y" axis. See Fig. 1.

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

3.1.7 *measurement coordinate system*—a mutually orthogo-nal 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. The orientation of the test objects is referenced to the measurement coordinate system. See Fig. 2.

3.1.8 *measurement plane*—an imaginary two-dimensional surface over which the HHMDs are tested. There may be more than one measurement plane. The measurement plane(s) is
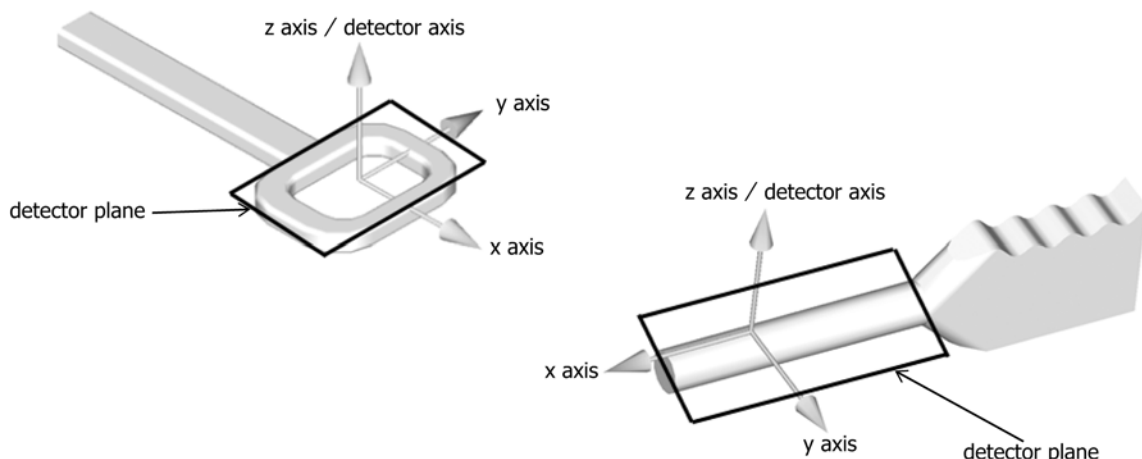

FIG. 1 Diagram of Hand-held Metal Detector Showing the Detector Plane (Labeled and Represented by a Rectangle) and the Detector Axis (Labeled z)
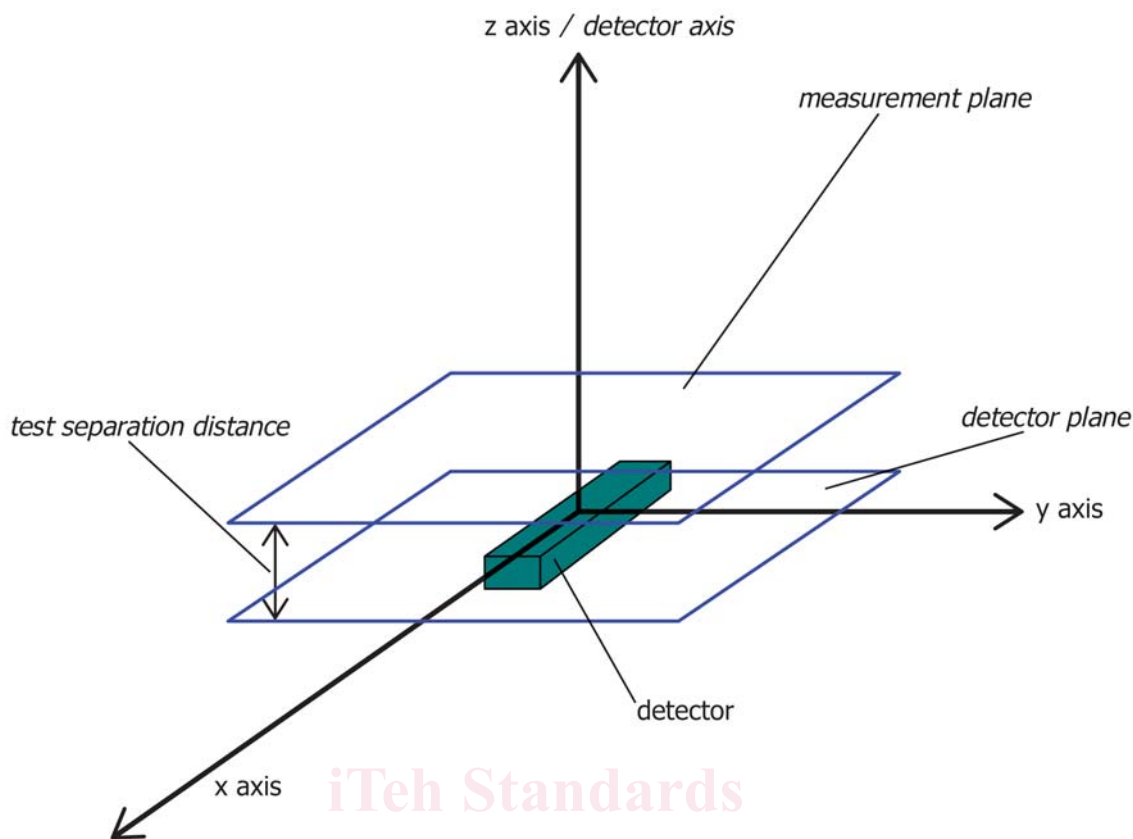
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FIG. 2 A Diagram of the Measurement Coordinate System Showing the Measurement Coordinate System Axes, One Measurement Plane, and the Detector Plane. The x axis Points Along the User's Arm

(are) referenced from the detector plane. See Fig. 2. There is a measurement plane for each size class of the HHMD, as shown in Table 1.

3.1.9 *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 HHMD may meet the requirements for one or all size classes, as defined below.

3.1.9.1 *large*—represents threat items such as handguns, and similarly sized objects, or larger, constructed of ferromagnetic or nonferromagnetic metal, or both.

3.1.9.2 *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, constructed of ferromagnetic or nonferromagnetic metal, or both.

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

Size Class	Distance Between Measurement Plane and Detector Plane (cm)
Large	8.0 − 0/+ 0.2
Medium	4.0 − 0/+ 0.2
Small	2.0 − 0/+ 0.2
Very Small	0.5 − 0/+ 0.2

3.1.9.3 *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, constructed of ferromagnetic or nonferromagnetic metal, or both.

3.1.9.4 *very small*—represents threat items such as t razor blades, hypodermic needles and similarly sized objects, up to the size of a small object, constructed of ferromagnetic or nonferromagnetic metals, or both.

3.1.10 *test object*—an item that is used to test the HHMD 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.

3.1.11 *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.

3.1.12 *x-axis scan range*—the segment of line along the x axis of the measurement coordinate system that is centered on the detector axis and that extends equally on either side of the detector axis.

4. Requirements for Acceptance

NOTE 1—The HHMD shall meet or exceed the requirements and specifications stated in this section. However, it is only to that HHMD unit

TABLE 2 X-axis Scan Range for the Different HHMD Size Classes

Size Class	X-axis Scan Range	
	lower limit (cm)	upper limit (cm)
Large	−7.5 ± 0.1	7.5 ± 0.1
Medium	−6.0 ± 0.1	6.0 ± 0.1
Small	−5.7 ± 0.1	5.7 ± 0.1
Very small	−5.4 ± 0.1	5.4 ± 0.1

under test and at the time of test that a pass/fail assignment can be made with confidence.

NOTE 2—To have confidence that the HHMD unit under test will pass/fail at times other than the time of the initial test or that other units of the same model will pass/fail requires model evaluation based on a product conformity assessment program, such as that described in Specification F3356 for Conformity Assessment of Metal Detectors Used in Safety and Securiity.

NOTE 3—Recommended test report forms are given in Appendix X5.

4.1 *General Test Conditions and Requirements:*

4.1.1 *Testing and Calibration Laboratories*—Laboratories performing testing and calibration of the HHMD 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, as amended.

4.2 *Safety Specifications and Requirements:*

4.2.1 *Magnetic Field Exposure*—The magnitude of the electromagnetic field generated by the HHMD shall be less than the exposure limits specified for general public exposure in the ICNIRP [8], [9] guidelines (see Appendix X4). These measurements shall be made at points on grid lines that are (*1*) tangential to the current-carrying coil of the HHMD and (*2*) parallel to the surfaces of an outward projection from the smallest imaginary rectangular prism enclosing that part of the HHMD encasing the current-carrying coils. The separation, s_{grid}, between points on these grid lines shall be 5 mm ± 1 mm and between any parallel tangential lines shall be 5 mm ± 1 mm. The separation between the outward-projected surface and the smallest imaginary rectangular prism shall be 5 mm ± 1 mm. A three-axis magnetic field probe with a −3 dB analog bandwidth of $0.1f_c \leq f_c \leq 10f_c$, where f_c is the nominal center frequency of the generated magnetic field, shall be used for measuring the magnetic field, and the size of its active elements shall be within a volume no larger than $2s_{grid} \times 2s_{grid} \times 2s_{grid}$. If the HHMD has not been demonstrated to meet this requirement, the manufacturer shall provide a warning with the HHMD instructions that states "This device has not been demonstrated as being safe or unsafe for use on people with active implanted or body-worn medical devices, or both."

4.3 *Power Requirement:*

4.3.1 *Battery Life*—The HHMD shall meet the detection performance specification given in 4.4 after operating for at least 10 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 HHMD to sense the presence of a test object will vary with the material and geometry of the test object and the distance between the test object and the HHMD. In this performance specification, the test objects are spherical to avoid the possibility of incorrectly attributing a higher performance capability to a HHMD than that HHMD is capable of providing. The test objects are grouped according to their size class and the HHMDs 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, 5.3, and 5.4 requirements shall be performed within an 8 h ± 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 HHMD shall exhibit an average probability of detection, $p_{d,sens,} \geq 0.95$ 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) and moving over the appropriate x-axis scan range (see Table 2) at a speed of 0.5 m/s ± 0.05 m/s and tested in accordance with 5.2.2. This requirement is met when $p_{LB} \geq p_{d,sens}$ as computed per 5.2.2.

4.4.2 *Detection Speed*—The HHMD shall exhibit an average probability of detection, $p_{d,sp\text{-}sens,} \geq 0.95$ 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) and moving over the appropriate x-axis scan range (see Table 2) for each required orientation (see Table 2) of the test object axes with respect to the measurement coordinate system at a speed of 0.05 m/s ± 0.01 m/s, 0.2 m/s ± 0.01 m/s, 0.5 m/s ± 0.01 m/s, and 1.0 m/s ± 0.01 m/s as tested in accordance with 5.2.2 under the following conditions: (*1*) the delay between subsequent tests of a given test object shall be no more than 5 s ± 0.5 s; and (*2*) the detector sensitivity setting shall not be readjusted between tests of a given test object or between tests of the test objects of a given size class. This requirement is met when $p_{LB,sp} \geq p_{d,sp\text{-}sens}$ as computed per 5.2.3.

4.5 *Interference Specifications and Requirements:*

4.5.1 *Metal Interference*—The HHMD, without adjusting the detection sensitivity settings used for the tests given in 4.4, shall exhibit a probability of false alarm, $p_{fa,m,} \leq 0.05$ with a confidence level of 0.95 when operating near a large metal plate, as tested in accordance with 5.3. This requirement is met when $p_{UB} \leq p_{fa,m}$ as computed per 5.3.2.

4.6 *Environmental Ranges and Conditions*—The HHMD or all of its components and their interconnections shall meet all of the requirements listed in this section. The HHMD shall

[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.

[9] ICNIRP "Guideline for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (1 Hz – 100 GHz), *Health Physics*, Vol 99 (6), pp. 818–836, 2010.

exhibit no observable changes in the detection performance specification given in 4.4.2 for the x-axis scan position of 0 cm and using the limited set of test objects listed in Section 6. The requirements given in this section shall be applied appropriately for either indoor or indoor/outdoor HHMD models. The tests for the requirements listed in this section shall be performed on the same unit.

4.6.1 *Temperature Stability and Range:*

4.6.1.1 *Indoor*—The HHMD shall operate over the ambient temperature range of at least 0 °C to 46 °C. The HHMD shall be tested in accordance with MIL-STD-810G Method 501.5, as amended, Procedure II, Steps 1 through 6, relative humidity 6 % ± 3 %, at 46 °C ± 3 °C. The HHMD then shall be cooled to 0 °C ± 3 °C within 4 h ± 0.5 h and tested in accordance with MIL-STD-810G Method 502.5, as amended, Procedure II, Steps 1 through 7.

4.6.1.2 *Indoor/Outdoor*—The HHMD shall operate over the ambient temperature range of at least –21 °C to 65 °C. The HHMD shall be tested in accordance with MIL-STD-810G Method 501.5, as amended, Procedure II, Steps 1 through 6, relative humidity 6 % ± 3 % at 65 °C ± 3 °C. The HHMD then shall be cooled to –21 °C ± 3 °C within 4 h ± 0.5 h and tested in accordance with MIL-STD-810G Method 502.5, as amended Procedure II, Steps 1 through 7.

4.6.2 *Ingress Protection:*

4.6.2.1 *Indoor*—The HHMD shall meet or exceed the requirements for compliance with IEC 60529, as amended, classification IP54.

4.7 *Mechanical Specifications and Requirements*—The HHMD or all of its components and their interconnections shall meet the requirements of the following standards. The requirements of 4.2 and 4.4 shall not be affected by the tests described in this section. All tests listed in this section shall be performed on the same unit. The HHMD shall exhibit no observable changes in the detection performance specification given in 4.4.1 for the x-axis scan position of 0 cm and using the limited set of test objects listed in Section 6.

4.7.1 *Free Fall*—The detector shall be tested in accordance with the requirements of IEC 60068-2-31, Procedure 1, as amended, for each direction of the detector axes, a fall height of 1 m, and for two drops for each direction of the orthogonal axes depicted in Fig. 2.

4.8 *Alarm Requirements*—At least one alarm type, vibratory, audible, or visual, shall be provided and any alarm provided shall meet the applicable requirement given in this section.

4.8.1 *Audible Alarm*—The audible alarms (other than an earphone), if provided, shall produce an alarm-state sound pressure level of 75 dB_{SPL} ± 5 dB (where 0 dB_{SPL} = 20 µPa root-mean-square in air) at 0.8 m ± 0.08 m from the HHMD as measured in accordance with 5.5.1. The audible alarm shall be either a frequency-proportional audible alarm or, optionally, a two-state audible alarm: active (alarm state) and inactive (nonalarm state).

5. Performance Testing Procedures

5.1 *General Test Conditions:*

5.1.1 *Test Location*—The distance between any metal object other than a test object (see Section 6) and the closest part of the HHMD shall be greater than 1.0 m.

5.1.2 *Environment*—At the time of the tests, the ambient temperature shall be in the range specified in 4.6 for the appropriate application (indoor or indoor/outdoor); the relative humidity shall be noncondensing.

5.1.3 *Preparations*—New or fully-charged batteries of the type listed in the operator's manual shall be installed at the beginning of the tests and as instructed in any test method. Any setup or calibration adjustments specified in the operator's manual shall be performed if required. In any stand-by feature is available on the HHMD, this feature shall be disabled.

5.2 *Detection Performance Tests*—The detection performance test methods described in this section are based on the use of a computer-controlled three-axis positioning system to control the motion and displacement of the test object relative to the HHMD. Other means of controlling this motion and displacement are acceptable if the positioning and speed values are within the tolerances specified in these test methods. If the HHMD can be adjusted to provide an alarm for more than one size class, the detection performance test shall be performed for each size class. The detection performance shall be evaluated by the test methods described in this section. The distinction in testing between the different size classes is the difference in the test separation distance between the measurement plane and the detector plane.

5.2.1 *Measurement System*—The measurement system shall contain the components necessary to perform the tests described herein. A diagram of the measurement system showing the electrical and mechanical connections between its components shall be provided.

5.2.2 *Detection Sensitivity Test:*

5.2.2.1 *Initial Procedures:*

(1) Turn on the measurement system and verify proper operation of the measurement system.

(2) Ensure that the HHMD is securely fixed to the detector holder and that the detector holder is fixed in position and secured to the measurement system.

(3) Attach the test object to the positioning component of the measurement system.

(4) Turn on the HHMD and ensure that its output is functioning properly by noting a change in the alarm output as a metal object is brought near the HHMD.

(5) Ensure that the test object does not hit the detector holder or any other objects while in motion.

(6) There is a minimum number of repeats of a given measurement that must be performed to meet the performance requirements for a given confidence interval. This minimum number of measurements, N_T, is given by:

$$N_T = \text{ceil}\left\{ \frac{z_c^2 p_0}{1 - p_0} \right\} \qquad (1)$$

where p_0 is equal to the probability of detection specified in 4.4.2; z_c is the critical point of a standard normal distribution and is fixed for a given confidence interval; and ceil{x} is a function that returns the smallest integer value that is greater than x. The value of N_T includes the number of test objects

of a given test object class, and the number of scans performed. For example, when $p_0 = 0.95$ and the confidence level = 0.95, $N_T = 52$. Values of N_T are provided for convenience in Appendix X3.

(7) Determine the number, $n_{s,k}$, of y-axis scans to perform at each x-axis position for a given test object and given the number, n_x, of practicable x-axis positions, and the total number of required scans, N_T. The values of $n_{s,k}$ is computed using:

$$n_{s,k} = \max\left\{\frac{N_T}{n_x}, \ 10\right\}, \tag{2}$$

where the function max{x,y} returns the maximum value of x and y.

5.2.2.2 *Performing the Measurement:*

(1) Prepare the measurement system to perform an x-y scan in the specified measurement plane at the specified speed. The center for the y-axis scans shall be the detector axis and the y-axis scans shall each be no less than 40 cm $\pm$ 1 cm long.

(2) Set the x-axis position to the specified lower x-axis scan range limit.

(3) Scan the y axis and record any alarm as the y-axis scan is being performed.

(4) Repeat Step *(3)* $n_{s,k}$ times to perform a total of $n_{s,k}$ scans for the current x-axis scan position.

(5) Compute the probability of alarm, $p_{d,sens,obj_k,x_i}$, where x_i is the x-axis scan position and i is the x-axis scan index, and obj_k represents the test object of the given test object class with index k, using:

$$p_{d,sens,k,i} = \frac{1}{n_{s,k}}\sum_{j=1}^{n_{s,k}} A_{Pos-sens,k,i,j} \tag{3}$$

where the index abbreviations: $k = obj_k$, and $i = x_i$ are used and $A_{Pos-sens,k,i,j}$ is an integer value representing the occurrence of the alarm (0 for the nonalarm state and 1 for the alarm state) for each x-axis scan position.

(6) Increment the x-axis position by 0.5 cm $\pm$ 0.1 cm.

(7) Repeat Steps *(3)* through *(6)* until the x-axis position is at the specified upper x-axis scan range limit and record the number of alarms at each x_i and N_x is the number of x-axis positions scanned.

(8) Repeat Step *(7)* for each of the remaining $K - 1$ test objects of a given size class, where K is the number of test objects in the size class.

(9) Upon completion of Step *(8)*, compute the average probability of detection, $p_{d,sens,}$ using:

$$p_{d,sens} = \frac{1}{KN_x}\sum_{k=1}^{K}\sum_{i=1}^{N_x} p_{d,sens,k,i}. \tag{4}$$

(10) Compute and record the average lower bound, p_{LB}, of $p_{d,sens}$ using:

$$p_{LB} = p_{d,sens} - \frac{\sqrt{\sum_{k=1}^{K}\sum_{i=1}^{N_x}(p_{d,sens,k,i} - l_{k,i})^2}}{KN_x}, \tag{5}$$

where

$$l_{k,i} = \frac{p_{k,i} + 0.5\frac{z_c^2}{n_{k,i}} - z_c\sqrt{\frac{p_{k,i}(1 - p_{k,i}) + \frac{z_c}{4n_{k,i}}}{n_{k,i}}}}{1 + \frac{z_c^2}{n_{k,i}}}, \tag{6}$$

where for these tests $n_{k,i} = n_{s,k}$ as computed in 5.2.2.1. For a 95 % confidence interval, $z_c = 1.645$ and for a 99 % confidence interval, $z_c = 2.576$.

(11) Set $p_d = P_{LB}$, and report this value.

5.2.3 *Detection Speed Test:*

5.2.3.1 *Initial Procedures:*

(1) Turn on the measurement system and verify proper operation of the measurement system.

(2) Ensure that the HHMD is securely fixed to the detector holder and that the detector holder is fixed in position and secured relative to the positioning component of the measurement system.

(3) Turn on the HHMD and ensure that its output is functioning properly by noting a change in the alarm output as a metal object is brought near the HHMD.

(4) Ensure that the test object does not hit the detector holder or any other objects while in motion.

(5) Use the value of N_T computed in Eq 1.

(6) Determine the number, $n_{s,k}$, of y-axis scans to perform at each x-axis position for a given test object and given the number, n_x, of practicable x-axis positions, the number, and total number of required scans, N_T. The value of $n_{s,k}$ is computed using:

$$n_{s,k} = \max\left\{\frac{N_T}{n_x}, \ 10\right\}, \tag{7}$$

where the function max{x,y} returns the maximum value of x and y.

5.2.3.2 *Performing the Measurement:*

(1) Prepare the measurement system to perform an x-y scan in the specified measurement plane at the specified speed. The center for the y-axis scans shall be the detector axis and the scans shall each be no less than 40 cm $\pm$ 1 cm long.

(2) Set the x-axis position to the specified lower x-axis scan range limit.

(3) Scan the y axis and record any alarm as the y-axis scan is being performed.

(4) Repeat Step *(3)* $n_{s,k}$ times to perform a total of $n_{s,k}$ scans for the current x-axis scan position.

(5) Compute the probability of alarm, $p_{d,sens,obj_k,x_i,s_m}$, where x_i is the x-axis scan position and i is the x-axis scan index, obj_k represents the test object of the given test object size class with index k, and s_m represents the different speeds with index m, using:

$$p_{d,sens,k,i,m} = \frac{1}{n_s}\sum_{j=1}^{n_s} A_{Pos-sens,k,i,m,j} \tag{8}$$

where the index abbreviations: $k = obj_k$, $i = x_i$, and $m = s_m$ are used and $A_{Pos-sens,k,i,m,j}$ is an integer value representing the occurrence of the alarm (0 for the nonalarm state and 1 for the alarm state) for each x-axis scan position.

(6) Increment the x-axis position by 0.5 cm ± 0.1 cm.

(7) Repeat Steps *(3)* through *(6)* until the x-axis position is at the specified upper x-axis scan range limit and record the number of alarms at each x_i, and N_x is the number of x-axis positions scanned.

(8) Repeat Step *(7)* for each of the remaining $K - 1$ test objects of a given size class, where K is the number of test objects in a given size class.

(9) Repeat Step *(8)* for each of the M test speeds.

(10) Upon completion of Step i, compute the average probability of detection, $p_{d,sp\text{-}sens}$, using:

$$p_{d,sp-sens} = \frac{1}{KN_xM} \sum_{k=1}^{K} \sum_{i=1}^{N_x} \sum_{m=1}^{M} p_{d,sens,k,i,m}. \qquad (9)$$

(11) Compute the average lower bound, $p_{LB,sp}$, of $p_{d,sp\text{-}sens}$ using:

$$p_{LB,sp} = p_{d,sp-sen} - \frac{\sqrt{\sum_{k=1}^{K} \sum_{i=1}^{N_x} \sum_{m=1}^{M} (p_{d,sens,k,i,m} - l_{k,i,m})^2}}{KN_xM}, \qquad (10)$$

where:

$$l_{k,i,m} = \frac{p_{k,i,m} + 0.5\frac{z_c^2}{n_{k,i,m}} - z_c \sqrt{\frac{p_{k,i,m}(1 - p_{k,i,m}) + \frac{z_c}{4n_{k,i,m}}}{n_{k,i,m}}}}{1 + \frac{z_c^2}{n_{k,i,m}}}, \qquad (11)$$

where for these tests $n_{k,i,m} = k_{s,k}$ as computed in 5.2.2.1. For a 95 % confidence interval, $z_c = 1.645$ and for a 99 % confidence interval $z_c = 2.576$.

(12) Record and report $p_{LB,sp}$.

5.3 *Metal Interference Test:*

5.3.1 *Initial Procedures:*

(1) The metal test panel shall be cold-finished sheet carbon steel UNS G10150 to G10200, 1 m ± 0.1 m by 1 m ± 0.1 m by 0.75 mm ± 0.13 mm thick. The panel shall be mounted or supported in a manner that keeps the panel flat.

(2) Use the value of N_T computed in Eq 1.

5.3.2 *Performing the Measurement:*

(1) Position the HHMD with its detector plane parallel to and 0.5 m ± 0.05 m from the plane of the test panel and with the detector axis centered with respect to the center of the test panel. Parallel is 0° ± 1°. Turn on the HHMD and without changing the HHMD performance settings note and perform a y-axis scan across the detector axis using the same parameters as in 5.2.2. Record any alarms. Repeat this y-axis scan $N_T - 1$ times to yield a total of N_T scans and compute the average alarm occurrence using:

$$p_{fa,m} = \frac{1}{N_T} \sum_{j=1}^{N_T} A_{Pos-m,j}, \qquad (12)$$

where $A_{Pos-m,j}$ is an integer value representing the occurrence of the alarm (0 for the nonalarm state and 1 for the alarm state), j is the scan repeat index, and $p_{fa,m}$ is the probability of false alarm for the metal interference test.

(2) Compute the upper bound, p_{UB}, of $p_{fa,m}$ using:

$$p_{UB} = \frac{p_{fa,m} + 0.5\frac{z_c^2}{N_T} + z_c \sqrt{\frac{p_{fa,m}(1 - p_{fa,m}) + \frac{z_c^2}{4N_T}}{N_T}}}{1 + \frac{z_c^2}{N_T}}. \qquad (13)$$

5.4 *Battery Life Test:*

5.4.1 *Initial Procedures:*

(1) Install in the HHMD new or fully charged batteries of the type specified by the manufacturer.

(2) Ensure that the alarm detector and positioning system are connected to the computer controller.

(3) Turn on the measurement system and verify proper operation of the measurement system.

(4) Ensure that the HHMD is securely fixed to the detector holder and that the detector holder is fixed in position and secured relative to the positioning component of the measurement system.

(5) Attach the test object with the proper orientation to the positioning system.

(6) Turn on the HHMD and ensure that its output is functioning properly by noting a change in the alarm output as a metal object is brought near the HHMD.

(7) Ensure that the test object does not hit the detector holder or any other objects while in motion.

5.4.2 *Performing the Measurement:*

(1) Prepare the measurement system to perform a series of y scans of a large size test object in the measurement plane for a large size test object at a speed of about 0.5 m/s. The center for the y-axis scans shall be the detector axis and the scans shall each be approximately 40 cm long. The duration of this series of scans shall be 10 h ± 0.1 h. The delay between scans shall be 30 s ± 2 s.

(2) After completion of Step *(1)*, perform ten y scans of a small size test object in the measurement plane for a small size test object at a speed of about 0.5 m/s. The center for the y-axis scans shall be the detector axis and the scans shall each be approximately 40 cm long. The delay between scans shall be less than 2 s. Compute the alarm rate, r_{alarm}, using:

$$r_{alarm} = \frac{N_{alarms}}{10}, \qquad (14)$$

where N_{alarms} is the number of alarms that were observed in step b.

(3) If $r_{alarm} \geq p_{d,sens}$, then record and report this as passing the battery life requirement, otherwise record and report as not passing the battery life requirement.

5.5 *Alarm Tests:*

5.5.1 *Audible Alarm Test:*

(1) Perform the test in an anechoic chamber. Position the sound pressure meter 0.80 m ± 0.02 m from the HHMD.

(2) Measure the sound pressure level, P_{na}, with the HHMD power applied and the alarm in the nonalarm state.

(3) Cause the HHMD to produce an alarm, and again measure and record the sound pressure level, P_{na+a}. Compute the sound pressure level generated by the alarm, P_a, using:

$$P_a = 10\log_{10}\left(10^{\frac{P_{na+a}}{10}} - 10^{\frac{P_{na}}{10}}\right). \qquad (15)$$

(4) Repeat this measurement five times and calculate the average value of P_a.

(5) Record and report the average P_a.

(6) For frequency proportional alarms, P_a shall be measured and reported at the following frequencies within the frequency band of the audible signal: lowest operational limit, f_{low}, of the audible alarm frequency band; highest operational limit, f_{hi}, of the audible alarm frequency bands; and the middle frequency, f_{mid}, where

$$f_{mid} = \frac{f_{hi}+f_{low}}{2}. \qquad (16)$$

6. Test Objects

6.1 The test objects are spherically shaped and constructed of either aluminum or steel. The diameters of these spherical test objects and the metal used for the different classification of HHMD performance are given in Table 3.

6.2 The electrical conductivity and magnetic relative permeability of the metals used in the construction of test objects is shown in Table 4. The test objects constructed for testing of the HHMD shall exhibit electrical conductivity and magnetic

TABLE 3 Sphere Diameters for the Test Objects Representing Different HHMD Detection Size Classifications that are Fabricated from a Nonferromagnetic Metal, Aluminum per UNS A96061, and a Ferromagnetic Metal, Steel per UNS G10180

Classification	Sphere Diameter	
	Aluminum, UNS A96061	Steel, UNS G10180
Class 1 (large size)	40 mm ± 0.1 mm	25 mm ± 0.1 mm
Class 2 (medium size)	15 mm ± 0.03 mm	12 mm ± 0.03 mm
Class 3 (small size)	9 mm ± 0.02 mm	7 mm ± 0.02 mm
Class 4 (very small size)	6 mm ± 0.01 mm	4 mm ± 0.01 mm

relative permeability values as shown in Table 2 within the tolerances shown in Table 4 with 95 % confidence for a nominal temperature of 20 °C ± 10 °C. The values shown with the footnoted references are based on values obtained in the literature; all other values are based on measurements performed at the National Institute of Standards and Technology.

7. Keywords

7.1 baseline performance; detection performance; detection sensitivity; detection speed; glove-type metal detector; hand-worn metal detector; metal detection; performance requirements; security; security screening; spherical test objects; test and evaluation

TABLE 4 Electromagnetic Properties of the Metals Used in the Construction of the Spherical Test Objects

Metal	UNS Designation	Electrical Conductivity (S/m)		Relative Magnetic Permeability	
		mean	tolerance	mean	tolerance
aluminum	UNS A96061	2.78×10^7	3.2×10^6	1	N/A
steel	UNS G10180	4.15×10^6	9.3×10^5	270[A]	30

[A]*Review of Quantitative Nondestructive Evaluation*, ed. by D.O. Thompson and D.E. Chimenti, Vol. 25, American Institute of Physics, 2006.

APPENDIXES

(Nonmandatory Information)

X1. TEST PROCEDURE FOR NON-SPHERICAL TEST OBJECTS (INFORMATIVE)

NOTE X1.1—This test procedure is provided to aid agencies wishing to measure the probability of detection of agency-specific non-spherical threat objects.

X1.1 *Detection Sensitivity Test, Non-Spherical Test Objects*—The user of the standard shall define three mutually orthogonal axes of the test object that are referenced to and have a one-to-one correspondence with the axes of the measurement coordinate system.

X1.1.1 *Initial Procedures:*

(1) Ensure that the alarm detector and positioning system are connected to the computer controller.

(2) Turn on the alarm detector, computer controller, and positioning system and verify proper operation of the measurement system.

(3) Ensure that the HHMD is securely attached to the detector holder and that the detector holder is fixed in position and secured relative to the three-axis positioning system.

(4) Attach the test object with the proper orientation to the positioning system.

(5) Turn on the HHMD and ensure that its output is functioning properly by noting a change in the alarm output as a metal object is brought near the HHMD.

(6) Ensure that the test object does not hit any objects while in motion.

(7) Use the value of N_T computed in Eq 1.

(8) Determine the number, $n_{s,k}$, of y-axis scans to perform at each x-axis position for a given test object and given the number, n_x, of practicable x-axis positions, the number, n_0, of orientations relative to the detector that are required for the test object (defined by the user of the standard), and the total number of required scans, n_T. The value of $n_{s,k}$ is computed using:

$$n_{s,k} = \max\left\{\frac{n_T}{n_x n_o}, 10\right\},\qquad \text{(X1.1)}$$

where the function $\max\{x,y\}$ returns the maximum value of x and y. Note, the value of n_o is dependent on the test object because each test object may have a different set of required orientations.

X1.1.2 *Performing the Measurement, X-axis Scan Range*:

(1) Set the computer program to perform an x-y scan in the specified measurement plane at the specified speed. The center for the y-axis scans shall be the detector axis and the scans shall each be no less than 40 cm $\pm$ 1 cm long.

(2) Set the x-axis position to the specified lower x-axis scan range limit.

(3) Scan the y axis and record any alarm as the y-axis scan is being performed.

(4) Repeat Step *(3)* $n_{s,k}$ times to perform a total of $n_{s,k}$ scans for the current x-axis scan position.

(5) Compute the probability of alarm, $p_{d,sens,obj_k,ornt_h,x_i}$, where x_i is the x-axis scan position and i is the x-axis scan index, $ornt_h$ is the orientation of the test object with orientation index h, and obj_k represents the test object of the given test object size class with index k, using:

$$p_{d,sens,k,h,i} = \frac{1}{n_s}\sum_{j=1}^{n_s} A_{Pos-sens,k,h,i,j}\qquad \text{(X1.2)}$$

where the abbreviations: $k = obj_k$, $h = ornt_h$, and $i = x_i$ are used and $A_{Pos-sens,k,h,i,j}$ is an integer value representing the occurrence of the alarm (0 for the nonalarm state and 1 for the alarm state) for each x-axis scan position.

(6) Increment the x-axis position by 0.5 cm $\pm$ 0.1 cm.

(7) Repeat Steps *(3)* through *(6)* until the x-axis position is at the specified upper x-axis scan range limit and record the number of alarms at each x_i, and N_x is the number of x-axis positions scanned.

(8) Repeat Steps *(2)* through *(7)* for the same test object and for each of the remaining $H - 1$ unique orientations of that test object, where H is the number of unique orientations of the test object specified for testing.

(9) Repeat Step *(8)* for each of the remaining $K - 1$ test object of a given size class, where K is the number of test objects in a given size class.

(10) Upon completion of Step *(9)*, compute the average probability of detection, $p_{d,sens}$, using:

$$p_{d,sens} = \frac{1}{KHN_x}\sum_{k=1}^{K}\sum_{h=1}^{H}\sum_{i=1}^{N_x} p_{d,sens,k,h,i}.\qquad \text{(X1.3)}$$

(11) Compute and record the average lower bound, p_{LB}, of $p_{d,sens}$ using:

$$p_{LB} = p_{d,sens} - \frac{\sqrt{\sum_{k=1}^{K}\sum_{h=1}^{H}\sum_{i=1}^{N_x}(p_{d,sens,k,h,i} - l_{k,h,i})^2}}{KHN_x},\qquad \text{(X1.4)}$$

where

$$l_{k,h,i} = \frac{p_{k,h,i} + 0.5 \dfrac{z_c^2}{n_{k,h,i}} - z_c \sqrt{\dfrac{p_{k,h,i}(1 - p_{k,h,i}) + \dfrac{z_c}{4 n_{k,h,i}}}{n_{k,h,i}}}}{1 + \dfrac{z_c^2}{n_{k,h,i}}},$$

(X1.5)

where for these tests $n_{k,h,i} = n_{s,k}$ as computed in 5.2.2.1. For

a 95 % confidence interval, $z_c = 1.645$ and for a 99 % confidence interval, $z_c = 2.326$.

(12) Set $p_d = p_{LB}$ and report this value.

X2. FIELD TESTING PROCEDURES (INFORMATIVE)

Note X2.1—The method is intended to ensure that the HHMD is working properly. It is not intended to replace the rigorous detection performance test methods described in Section 5. The field testing procedure should be conducted, at a minimum, at the beginning of each 8-h working period.

X2.1 Equipment

X2.1.1 *Field Test Object*—The field test object is a test object that has either been provided by the manufacturer for field performance verification or one that the agency has defined as appropriate for the purpose of field performance verification.

X2.1.2 *Manufacturer Supplied Field Test Object*—This test object should be stored in a secure location to prevent an inadvertent contact that may affect its electromagnetic properties.

X2.1.3 *Agency Supplied Field Test Object*—This test object can be either a unique item, which should be stored so as to prevent an inadvertent change to its electromagnetic properties, or a type of item that the agency has identified as appropriate. In the latter case, the item may be one that is commonly found in the agency's facility or carried by an officer of that agency.

X2.1.4 *Clean Hand*—The clean hand is the hand of the operator of the HHMD that does not grip the HHMD. This hand and its arm shall be free of metal from the elbow to the tip of the fingers on this hand.

X2.2 Procedures

(1) Hold the HHMD with the appropriate hand and ensure it is held according to the manufacturer's instructions. Activate the HHMD using the on button or switch.

(2) Wave the HHMD over the clean hand and note any alarm. Repeat this test several times to ensure the HHMD is adequately tested. If the HHMD consistently alarms on the clean hand, it is not operating properly and may provide a high false alarm rate.

(3) Hold the field test object in the palm of the open clean hand. Wave the HHMD over field test object at a distance of about 2 cm, or as specified by the manufacturer, above the test object and note any alarm.

(4) Repeat this test several times to ensure the HHMD is adequately tested.

(5) If the HHMD consistently fails to alarm, it is not operating properly and should be taken out of service.

X3. TABLE OF THE NUMBER OF REPEATED TESTS, N_T (INFORMATIVE)

X3.1 A table of the values of the number of repeated tests, N_T, for difference confidence intervals and probabilities is given here to guide and help the user of the standard. The yellow highlighted row and column refers to the confidence interval and probability values used as examples in the

different test procedures of this standard. If discrepancies occur between calculations of N_T by the user of the standard and the values in Table X3.1, the user-calculated value should be used, which is computed using Eq 1.

TABLE X3.1 Value of N_T for Different Probability Values and Confidence Intervals

		0.7	0.8	0.81	0.82	0.83	0.84	0.85	0.86	0.87	0.88	0.89	0.9	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99
	0.7	1	2	2	2	2	2	2	2	2	3	3	3	3	4	4	5	6	7	9	14	28
	0.75	2	2	2	3	3	3	3	3	4	4	4	5	5	6	7	8	9	11	15	23	46
	0.76	2	2	3	3	3	3	3	4	4	4	5	5	6	6	7	8	10	12	17	25	50
	0.77	2	3	3	3	3	3	4	4	4	5	5	5	6	7	8	9	11	14	18	27	55
	0.78	2	3	3	3	3	4	4	4	5	5	5	6	7	7	8	10	12	15	20	30	60
	0.79	2	3	3	3	4	4	4	4	5	5	6	6	7	8	9	11	13	16	22	32	65
	0.8	2	3	4	4	4	4	5	5	5	6	6	7	8	9	10	12	14	17	23	35	71
	0.81	2	4	4	4	4	5	5	5	6	6	7	7	8	9	11	13	15	19	25	38	77
	0.82	2	4	4	4	5	5	5	6	6	7	7	8	9	10	12	14	16	21	28	42	83
	0.83	3	4	4	5	5	5	6	6	7	7	8	9	10	11	13	15	18	22	30	45	91
	0.84	3	4	5	5	5	6	6	7	7	8	9	9	10	12	14	16	19	24	32	49	98
Confidence Interval	0.85	3	5	5	5	6	6	7	7	8	8	9	10	11	13	15	17	21	26	35	53	107
	0.86	3	5	5	6	6	7	7	8	8	9	10	11	12	14	16	19	23	29	38	58	116
	0.87	3	6	6	6	7	7	8	8	9	10	11	12	13	15	17	20	25	31	42	63	126
	0.88	4	6	6	7	7	8	8	9	10	11	12	13	14	16	19	22	27	34	45	68	137
	0.89	4	7	7	7	8	8	9	10	11	12	13	14	16	18	20	24	29	37	49	74	149
	0.9	4	7	8	8	9	9	10	11	11	13	14	15	17	19	22	26	32	40	54	81	163
	0.91	5	8	8	9	9	10	11	12	13	14	15	17	19	21	24	29	35	44	59	89	178
	0.92	5	8	9	9	10	11	12	13	14	15	16	18	20	23	27	31	38	48	64	97	196
	0.93	6	9	10	10	11	12	13	14	15	16	18	20	23	26	29	35	42	53	71	107	216
	0.94	6	10	11	12	12	13	14	15	17	18	20	22	25	28	33	38	46	59	79	119	240
	0.95	7	11	12	13	14	15	16	17	19	20	22	25	28	32	36	43	52	65	88	133	268
	0.96	8	13	14	14	15	17	18	19	21	23	25	28	31	36	41	49	59	74	100	151	304
	0.97	9	15	16	17	18	19	21	22	24	26	29	32	36	41	47	56	68	85	115	174	351
	0.98	10	17	18	20	21	23	24	26	29	31	35	38	43	49	57	67	81	102	137	207	418
	0.99	13	22	24	25	27	29	31	34	37	40	44	49	55	63	72	85	103	130	175	266	536

X4. SAFETY LIMITS FOR GENERATED MAGNETIC FIELD (INFORMATIVE)

X4.1 This appendix addresses the limits of the magnetic field intensity that is generated by hand-held metal detectors (HHMDs). The maximum magnetic field generated by HHMDs should not exceed the lowest susceptibility requirement for the different medical electronic devices or the maximal permissible exposure (MPE) published values for magnetic field intensity (H, in using of A/m), whichever is least. For determining the limit of HHMD magnetic field intensity, both the values from Table X4.1 and the published MPE values are used. In summary, the reference levels for general-public exposure given in the ICNIRP Guidelines provides the lowest acceptable susceptibility to magnetic field intensity compared to the other susceptibility standards and, therefore, is used to define the maximum allowed intensity for the magnetic fields generated by HHMDs.

X4.2 ICNIRP published updated reference levels for frequencies below 100 kHz in 2010. However, the magnetic-field susceptibility requirements for active-implantable-medical-device standards are typically equal to or greater than the ICNIRP 1998 reference levels for general-public exposure. A comparison of the different values is shown graphically in Fig. X4.1. The values for H as a function of frequency, from the ICNIRP guidelines, are also given in Table X4.2. This standard only considers, at this revision, single-frequency sinusoidal magnetic fields.

TABLE X4.1 Susceptibility Limits for Medical Electronic Devices for Magnetic Field Exposure

NOTE 1—The values for this table are taken from the following standards: ISO 14708-2:2012, ISO 14708-3:2008, ISO 14708-4:2008, ISO 14708-5:2010, ISO 14708-6:2010, and ISO 14708-7:2013.

	non-ionizing EM (H rms)	
	1 kHz ≤ f ≤ 100 kHz	100 kHz < f ≤ 140 kHz
ISO 14708-2:2012	150 A/m	$150\left[\dfrac{100}{f(\text{kHz})}\right]$ A/m
	from Clause 4.8 of ISO 14117:2012	
	3 kHz ≤ f ≤ 100 kHz	100 kHz < f ≤ 30 MHz
	emissions outside of generated band	
ISO 14708-3:2008	15.9 A/m	$\dfrac{1590}{f(\text{kHz})}$ A/m
	emissions within generated band	
	159 A/m	$\dfrac{15900}{f(\text{kHz})}$ A/m
	3 kHz ≤ f ≤ 100 kHz	100 kHz < f ≤ 30 MHz
	emissions outside of generated band	
ISO 14708-4:2008	15.9 A/m	$\dfrac{1590}{f(\text{kHz})}$ A/m
	emissions within generated band	
	159 A/m	$\dfrac{15900}{f(\text{kHz})}$ A/m
	3 kHz ≤ f ≤ 100 kHz	100 kHz < f ≤ 30 MHz
	emissions outside of generated band	
ISO 14708-5:2010	15.9 A/m	$\dfrac{1590}{f(\text{kHz})}$ A/m
	emissions within generated band	
	159 A/m	$\dfrac{15900}{f(\text{kHz})}$ A/m
	3 kHz ≤ f ≤ 100 kHz	100 kHz < f ≤ 30 MHz
	emissions outside of generated band	
ISO 14708-6:2010	15.9 A/m	$\dfrac{1590}{f(\text{kHz})}$ A/m
	emissions within generated band	
	159 A/m	$\dfrac{15900}{f(\text{kHz})}$ A/m
ISO 14708-7:2013	Table 101 — Peak magnetic field strength Hp	

Table 101 — Peak magnetic field strength Hp

Frequency	Peak magnetic field strength Hp			
	Lower level	Burst-on time	Upper level	Burst-on time
16.6 Hz	340 A/m	cw	480 A/m	cw
50 Hz	110 A/m	cw	1 200 A/m	cw
1.66 kHz	7.0 A/m	10 ms	150 A/m	10 ms
5 kHz	7.0 A/m	10 ms	150 A/m	10 ms
16.6 kHz	7.0 A/m	10 ms	150 A/m	10 ms
50 kHz	7.0 A/m	10 ms	150 A/m	10 ms
166 kHz	7.0 A/m	10 ms	110 A/m	10 ms
500 kHz	4.0 A/m	3 ms	26 A/m	1.5 ms
1.66 MHz	2.0 A/m	1 ms	5.5 A/m	200 µs
5 MHz	0.15 A/m	500 µs	2.9 A/m	50 µs

NOTE: The fields do not have to be homogenous.

hand-held metal detectors will not typically be used to search near the head, so these requirements are not applicable

12
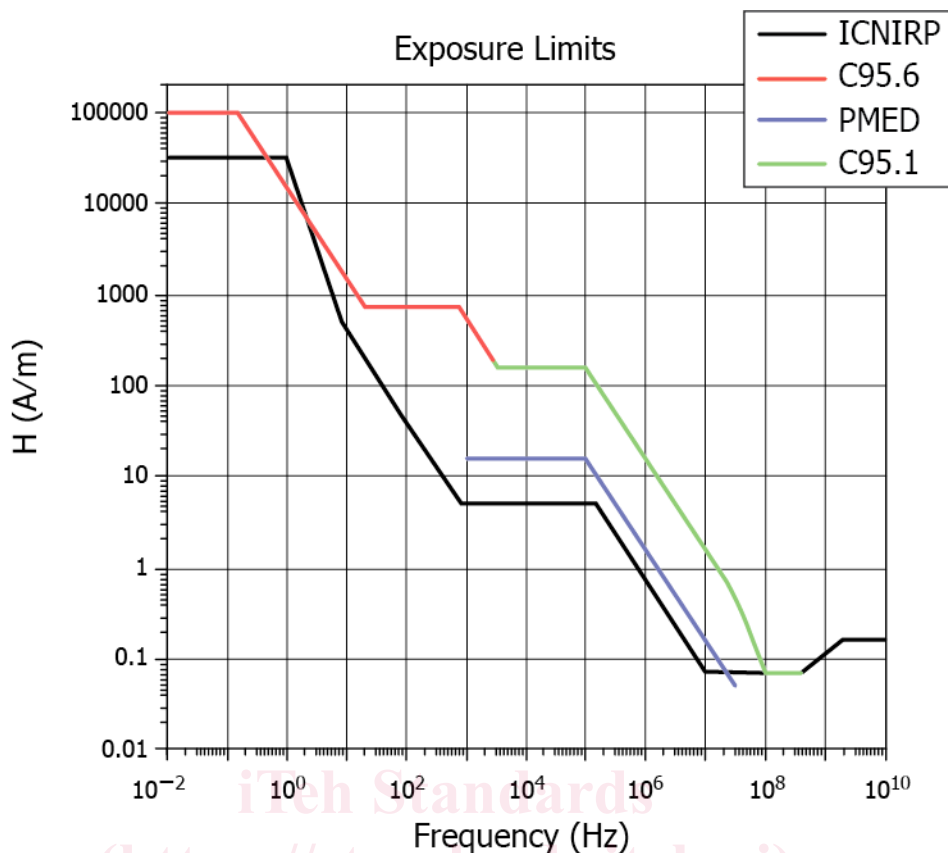
Exposure Limits

ICNIRP Guideline[8]
IEEE C95.6
PMED—values from Table X4.1
IEEE C95.1

FIG. X4.1 Exposure Limits Taken from Different Documentary Standards

**TABLE X4.2 Generation Limits for the Magnetic Field Intensity
from Hand-held Metal Detectors**

Magnetic field intensity, H (A/m)	Frequency, f
3.2×10^4	$f < 1$ Hz
$3.2 \times 10^4/f^2$	1 Hz $\leq f < 8$ Hz
$4000/f$	8 Hz $\leq f < 800$ Hz
5	800 Hz $\leq f < 150 \times 10^3$ Hz
$7.3 \times 10^5/f$	150×10^3 Hz $\leq f < 10 \times 10^6$ Hz

X5. ASTM F3278 INITIAL CERTIFICATION TEST REPORT AND DATA SHEETS HAND-HELD METAL DETECTOR (INFORMATIVE)

Note X5.1—If the certification body has accepted in their conformity assessment program, certification from other ISO 17065 accredited certification bodies for requirements in ASTM standard that are described in other standards, the data sheet for those requirements as described here are not required.