



# National Institute of Justice

Law Enforcement and Corrections Standards and Testing Program

## **Walk-Through Metal Detectors for Use in Concealed Weapon and Contraband Detection**

**NIJ Standard-0601.01**

## ABOUT THE LAW ENFORCEMENT AND CORRECTIONS STANDARDS AND TESTING PROGRAM

The Law Enforcement and Corrections Standards and Testing Program is sponsored by the Office of Science and Technology of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which directed NIJ to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

The Law Enforcement and Corrections Standards and Testing Program is an applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationally and internationally.

The program operates through:

The *Law Enforcement and Corrections Technology Advisory Council (LECTAC)*, consisting of nationally recognized criminal justice practitioners from Federal, State, and local agencies, which assesses technological needs and sets priorities for research programs and items to be evaluated and tested.

The *Office of Law Enforcement Standards (OLES)* at the National Institute of Standards and Technology, which develops voluntary national performance standards for compliance testing to ensure that individual items of equipment are suitable for use by criminal justice agencies. The standards are based upon laboratory testing and evaluation of representative samples of each item of equipment to determine the key attributes, develop test methods, and establish minimum performance requirements for each essential attribute. In addition to the highly technical standards, OLES also produces technical reports and user guidelines that explain in nontechnical terms the capabilities of available equipment.

The *National Law Enforcement and Corrections Technology Center (NLECTC)*, operated by a grantee, which supervises a national compliance testing program conducted by independent laboratories. The standards developed by OLES serve as performance benchmarks against which commercial equipment is measured. The facilities, personnel, and testing capabilities of the independent laboratories are evaluated by OLES prior to testing each item of equipment, and OLES helps the NLECTC staff review and analyze data. Test results are published in Equipment Performance Reports designed to help justice system procurement officials make informed purchasing decisions.

Publications are available at no charge through the National Law Enforcement and Corrections Technology Center. Some documents are also available online through the Internet/World Wide Web. To request a document or additional information, call 800-248-2742 or 301-519-5060, or write:

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## **Walk-Through Metal Detectors for Use in Concealed Weapon and Contraband Detection**

### **NIJ Standard-0601.01**

*Supersedes NILECJ-STD-0601.00 dated June 1974*

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## **National Institute of Justice**

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This standard was formulated by the Office of Law Enforcement  
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and Technology (NIST) under the direction of  
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of the standard was written by Nicholas G. Paulter of NIST.  
The work resulting in this standard was sponsored by  
the National Institute of Justice, Dr. David G. Boyd,  
Director, Office of Science and Technology.

## FOREWORD

This document, NIJ Standard–0601.01, Walk-Through Metal Detectors for Use in Concealed Weapon and Contraband Detection, is an equipment standard developed by the Office of Law Enforcement Standards of the National Institute of Standards and Technology. It is produced as part of the Law Enforcement and Corrections Standards and Testing Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment should meet to satisfy the needs of criminal justice agencies for high-quality service. Purchasers can use the test methods described in this standard to determine whether a particular piece of equipment meets the essential requirements, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements. Compliance with the requirements of the standard may be verified by an independent laboratory or guaranteed by the vendor.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. User guides have also been published for those who seek general guidance concerning the selection and application of law enforcement equipment. The guides explain in nontechnical language how to select equipment capable of the performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Director, Office of Science and Technology, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Director, Office of Law Enforcement Standards, National Institute of Standards and Technology, 100 Bureau Drive, Stop 8102, Gaithersburg, MD 20899–8102.

Dr. David G. Boyd, Director  
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## BACKGROUND

Following a congressional mandate (Section 402(b) of the Omnibus Crime Control and Safe Streets Act of 1968, as amended) to develop new and improved techniques, systems, and equipment to strengthen law enforcement and criminal justice, in the early 1970s, the National Institute of Law Enforcement and Criminal Justice (NILECJ) established the Law Enforcement Standards Laboratory (LESL) at the National Bureau of Standards (NBS). LESL's function was to conduct research that would assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

In response to priorities established by NILECJ, LESL (1) subjected existing equipment to laboratory testing and evaluation and (2) conducted research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys, and other reports.

In June 1974, NILECJ, a predecessor organization to the National Institute of Justice (NIJ), promulgated a standard for walk-through metal detectors which consisted of performance and other requirements together with a description of appropriate test methods. This document, NILECJ-STD-0601.00, Walk-Through Metal Detectors for Use in Weapons Detection, was a law enforcement equipment standard developed by LESL and approved and issued by NILECJ.

The Law Enforcement and Corrections Technology Advisory Council (LECTAC), a technical advisory group to NIJ, recommended that NIJ revise the NILECJ-STD-0601.00, Walk-Through Metal Detectors for Use in Weapons Detection. Revisions were also requested by a number of the manufacturers of the detectors. Subsequently, NIJ contacted the Office of Law Enforcement Standards (OLES), formerly LESL, of the National Institute of Standards and Technology (NIST), formerly NBS, to develop these revised standards in coordination with the law enforcement and corrections (LEC) community.

In response to this request, NIST contacted a large number of medium to large LEC agencies (in numbers of sworn officers) to discuss their concerns and recommendations for improved standards. On the basis of these discussions and a review of other agency/organization standards, the following standard, "National Institute of Justice Standard for Walk-Through Metal Detectors for Use in Concealed Weapon and Contraband Detection," was adopted.

This equipment standard is a technical document consisting of performance and other requirements together with a description of test methods. Equipment that can meet the requirements stated herein will meet most if not all of the performance and functional requirements of the LEC community. Purchasing agents can use the test results described in this standard to determine firsthand whether a particular equipment item meets the requirements of the standard, or they may have the tests conducted on their behalf by a qualified testing laboratory. LEC personnel may also reference this standard in procurement documents and

require that any equipment offered for purchase meet its requirements and that this compliance be either guaranteed by the vendor or attested to by an independent testing laboratory.

The necessarily technical nature of this NIJ standard makes it of limited use to those who seek general information concerning walk-through metal detectors. For purchasing agents and other interested persons who need information on the operation of walk-through metal detectors, a user's guide is available. The guide provides, in nontechnical language, information for purchasing agents and other interested persons concerning the capabilities of equipment currently available, along with other useful information and can be obtained by contacting OLES/NIST or NIJ.

## ACKNOWLEDGMENTS

This document, NIJ Standard–0601.01, “Walk-Through Metal Detectors for Use in Concealed Weapon and Contraband Detection,” is the result of inputs from the law enforcement and corrections (LEC) community regarding the functional and performance requirements of walk-through weapon detectors required to maintain and improve the security of correctional and public buildings and to improve the safety of the officers involved. In particular, the following local and State LEC agencies provided inputs that were used in rewriting the standard:

Allen County Sheriff's Department, Fort Wayne, IN  
Arapahoe County Sheriff's Department, Littleton, CO  
Buffalo Police Department, Buffalo, NY  
California Department of Corrections, Sacramento, CA  
Erie County Sheriff's Department, Erie County, NY  
Fairfax County Sheriff's Department, Fairfax, VA  
Frederick County Adult Detention Center, Frederick, MD  
Los Angeles County Sheriff's Department, Monterey Park, CA  
Montgomery County Police, Rockville, MD  
New Hampshire Department of Corrections, Concord, NH  
New York State Department of Corrections, Buffalo, NY  
Rhode Island Department of Corrections, Cranston, RI  
Rome Police Department, Rome, NY

The following Federal LEC agencies provided comments and inputs regarding the contents of the standard:

Bureau of Alcohol, Tobacco and Firearms, U.S. Department of Treasury  
Bureau of Diplomatic Security, U.S. Department of State  
Federal Aviation Administration, U.S. Department of Transportation  
Federal Bureau of Investigation, U.S. Department of Justice  
Federal Bureau of Prisons, U.S. Department of Justice  
United States Secret Service, U.S. Department of Treasury



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## COMMONLY USED SYMBOLS AND ABBREVIATIONS

A	ampere	H	henry	nm	nanometer
ac	alternating current	h	hour	No.	number
AM	amplitude modulation	hf	high frequency	o.d.	outside diameter
cd	candela	Hz	hertz (c/s)	$\Omega$	ohm
cm	centimeter	i.d.	inside diameter	p.	page
CP	chemically pure	in	inch	Pa	pascal
c/s	cycle per second	IR	infrared	pe	probable error
d	day	J	joule	pp.	pages
dB	decibel	L	lambert	ppm	parts per million
dc	direct current	L	liter	qt	quart
C	degree Celsius	lb	pound	rad	radian
F	degree Fahrenheit	lbf	pound-force	rf	radio frequency
dia	diameter	lbf in	pound-force inch	rh	relative humidity
emf	electromotive force	lm	lumen	s	second
eq	equation	ln	logarithm (base e)	SD	standard deviation
F	farad	log	logarithm (base 10)	sec.	section
fc	footcandle	M	molar	SWR	standing wave ratio
fig.	figure	m	meter	uhf	ultrahigh frequency
FM	frequency modulation	min	minute	UV	ultraviolet
ft	foot	mm	millimeter	V	volt
ft/s	foot per second	mph	miles per hour	vhf	very high frequency
g	acceleration	m/s	meter per second	W	watt
g	gram	N	newton	$\lambda$	wavelength
gr	grain	N m	newton meter	wt	weight

area=unit<sup>2</sup> (e.g., ft<sup>2</sup>, in<sup>2</sup>, etc.); volume=unit<sup>3</sup> (e.g., ft<sup>3</sup>, m<sup>3</sup>, etc.)

### PREFIXES

d	deci (10 <sup>-1</sup> )	da	deka (10)
c	centi (10 <sup>-2</sup> )	h	hecto (10 <sup>2</sup> )
m	milli (10 <sup>-3</sup> )	k	kilo (10 <sup>3</sup> )
$\mu$	micro (10 <sup>-6</sup> )	M	mega (10 <sup>6</sup> )
n	nano (10 <sup>-9</sup> )	G	giga (10 <sup>9</sup> )
p	pico (10 <sup>-12</sup> )	T	tera (10 <sup>12</sup> )

### COMMON CONVERSIONS (See ASTM E380)

0.30480 m = 1ft	4.448222 N = 1 lbf
2.54 cm = 1 in	1.355818 J = 1 ft lbf
0.4535924 kg = 1 lb	0.1129848 N m = 1 lbf in
0.06479891g = 1gr	14.59390 N/m = 1 lbf/ft
0.9463529 L = 1 qt	6894.757 Pa = 1 lbf/in <sup>2</sup>
3600000 J = 1 kW hr	1.609344 km/h = 1 mph

$$\text{Temperature: } T_C = (T_F - 32) \times 5/9$$

$$\text{Temperature: } T_F = (T_C \times 9/5) + 32$$

**NIJ STANDARD  
FOR  
WALK-THROUGH METAL DETECTORS FOR USE IN  
CONCEALED WEAPON AND CONTRABAND DETECTION**

**1. INTRODUCTION**

**1.1 Purpose of the Standard**

The purpose of this document is to establish performance requirements and methods of test for active walk-through metal detectors used to find metal weapons and/or metal contraband carried on a person and/or concealed by a nonmetal object.

**1.2 Definitions**

The definitions given herein are for the purpose of this document and are written to facilitate the use and understanding of this document, which relates to active walk-through metal detectors for use as weapon detectors. Terms that are defined here appear in *italics* in the remainder of this document.

All measurement units used in this document are metric. Length units are abbreviated: meter (m), centimeter (cm), and millimeter (mm). Where useful, English units are indicated in parentheses immediately following the metric units, such as “2.54 cm (1 in).”

**1.2.1 Alarm Indication**

A signal to warn of the detection of a metal object. The indication can be visual and/or auditory.

**1.2.1.1 Positive Alarm Indication**

The change in the *alarm indication* that corresponds to the detection of a metal object. Typically, the *alarm indication* is off until a metal object is detected.

**1.2.1.2 Proportional Alarm Indication**

An *alarm indication* proportional to the size, proximity, orientation, and material of an object.

### **1.2.2 Alarm Indicator**

The device used to generate the *alarm indication*. For a visual indication, the alarm generating device can be a light bulb, lamp, light emitting diode, etc. For an auditory indication, the alarm generating device can be a horn, siren, buzzer, etc.

### **1.2.3 Active Detector**

An *active detector* is, in general, a device that generates and emits energy for illuminating the portal region of the detector. For the walk-through metal detector, the emitted energy is in the form of a magnetic field. The interaction of the emitted magnetic field with certain types of objects in the portal region of the detector and the ability to detect this interaction is the basis of operation for walk-through metal detectors.

### **1.2.4 Clean Tester**

A person who does not carry any electrically conductive and magnetizable objects such as metallic belt buckles, metal buttons, cardiac pacemaker, coins, metal-frame eyeglasses, hearing aid, jewelry, keys, pens and pencils, shoes with metal arches or supports, metallic surgical implants, undergarment support metal, metal zippers, etc., which would significantly alter the signal produced when the person carries a *test object*.

### **1.2.5 Detection**

The discovery or finding of a metallic object. The detection of a metallic object is transmitted to the operator by some type of *alarm indicator*, typically a visual or audible indicator.

### **1.2.6 Detector Axis**

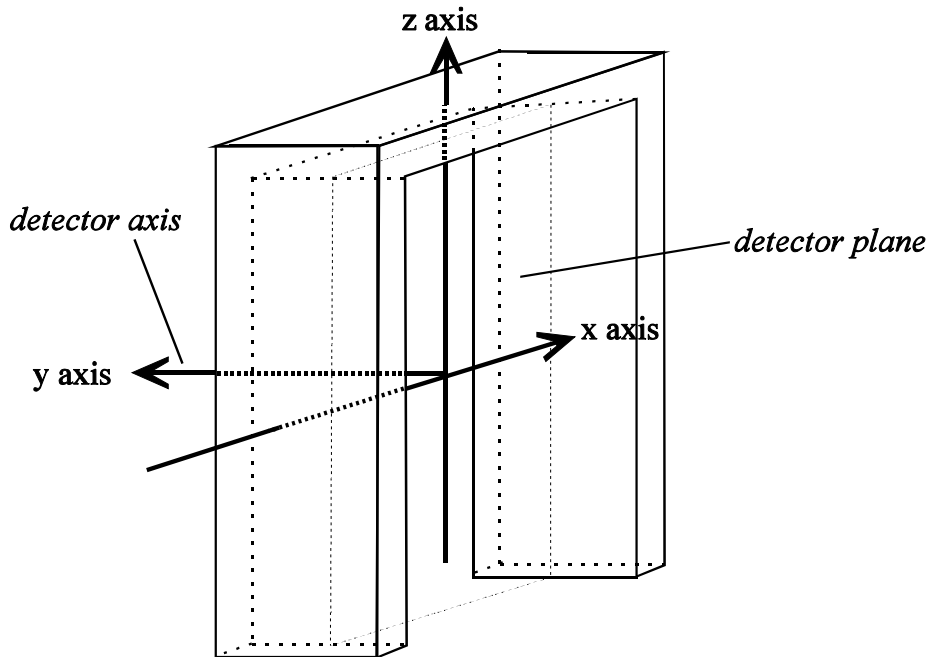
An imaginary line passing through and perpendicular to the *detector plane* that is centered vertically and horizontally within the portal of the walk-through metal detector and points in the direction of the subject's motion through the portal. See figure 1.

### **1.2.7 Detector Floor**

The bottom plane of the detector portal.

### **1.2.8 Detector Mount**

A nonconductive, nonmagnetic platform on which the walk-through metal detector rests. The *detector mount* locates the *detector floor* at a height of 15 cm (6 in) and contains grooves at 5 cm (2 in) to facilitate the metal floor test required under section 3.5.2. The *reference surface*



**Figure 1. Diagram of walk-through metal detector showing the detector plane, the detector axis, and the x, y, and z axes of the measurement coordinate system**

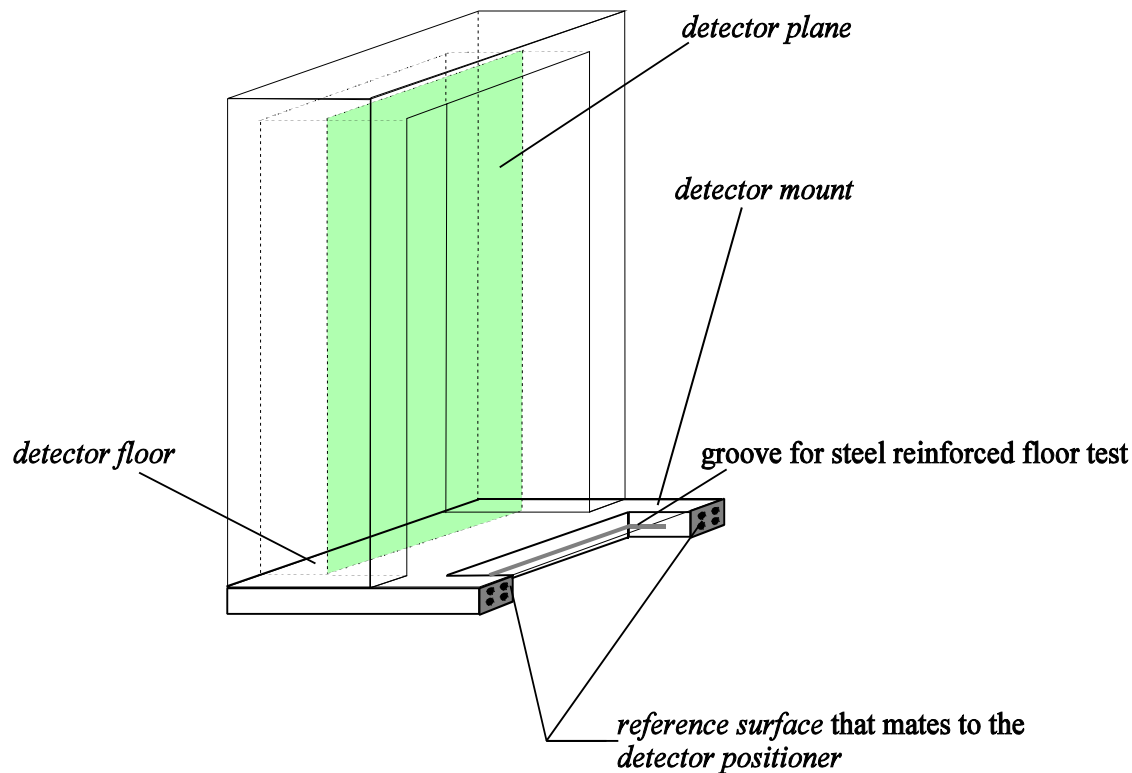
of the *detector mount* is parallel to the *detector plane*, contains tapped holes that mate to the mounting holes of the positioning system (see sec. 3.2.2.2), and holds the *detector plane* 0.5 m (1.7 ft) from the *reference surface*. The *detector mount* is supplied by the manufacturer and attached to the *detector positioner* at their *reference surfaces*. See figure 2.

### 1.2.9 Detector Plane

An imaginary plane (two-dimensional surface) that is parallel to the portal of the walk-through metal detector and that bisects the sensor region into two symmetric halves. The *detector plane* contains two orthogonal axes labeled the “x” axis and the “z” axis. See figure 1.

### 1.2.10 Detector Positioner

A nonconductive, nonmagnetic device that fixes the position of the *detector plane* and *detector axis* with respect to the *three-axes translation system*. The *detector positioner* includes a *reference surface* for attaching the *detector mount*. The *detector positioner* also includes a surface for attachment to the *three-axes translation system*.



**Figure 2. Diagram showing the detector and the detector mount, the detector plane, the detector floor, and the reference surface**

### **1.2.11 Detector Response**

The electrical signal generated by the sensor or sensor circuit of the detector and caused by an object interacting with the magnetic field emitted by the detector. The *detector response* is the basis on which an *alarm indication* is derived.

### **1.2.12 Ground Surface**

The surface on which the walk-through detector rests.

### **1.2.13 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 y axis is parallel to the *detector axis* and the x and z axes are in the *detector plane*. The orientation of the *test objects* and direction of the magnetic field is referenced to the *measurement coordinate system*. See figure 1.

#### **1.2.14 Object Size Classes**

A classification method based on the ability to detect metal objects of a minimum size. A detector may meet the requirements for one or both *object size classes*, as defined below.

##### **1.2.14.1 Large Object Size**

The ability to detect guns and large knives concealed on an individual that are constructed of either ferromagnetic or nonferromagnetic metal. Large knives are defined for this purpose as knives with blade lengths exceeding 7.5 cm.

##### **1.2.14.2 Medium Object Size**

The ability to detect small weapons and contraband items concealed on an individual that are constructed of either ferromagnetic or nonferromagnetic metal. Small weapons and contraband items are defined as any item that can be used to injure another person or to defeat security devices. Objects in this category include razor blades, hacksaw blades, handcuff keys, etc.

#### **1.2.15 Reference Surface**

The planes located on the *detector mount* and *detector positioner* used to attach the *detector mount* and *detector positioner*. See figure 2.

#### **1.2.16 Test Object**

An item used to test the walk-through detection performance. The *test object* is an encased replica of a metallic item that is either a weapon, can be used as a weapon, or can be used to defeat security devices. The shape of the encasement is a parallelepiped. The encasement has up to 12 holes that allow the replica to be oriented with respect to the *measurement coordinate system*; no more than nine possible orientations are allowed, one to three orientations for each, but no more than three, unique orthogonal surfaces of the parallelepiped.

##### **1.2.16.1 Large Object Size Test Objects**

*Test objects* used to test the *large object size* detection performance of walk-through metal detectors used as weapon detectors. Mechanical drawings of the *large size test objects* are provided in section 5.1.

##### **1.2.16.2 Medium Object Size Test Objects**

*Test objects* used to test the *medium object size* detection performance of walk-through metal detectors used as weapon detectors. Mechanical drawings of the *medium size test objects* are provided in section 5.2.



### 1.2.16.3 Innocuous Item Test Objects

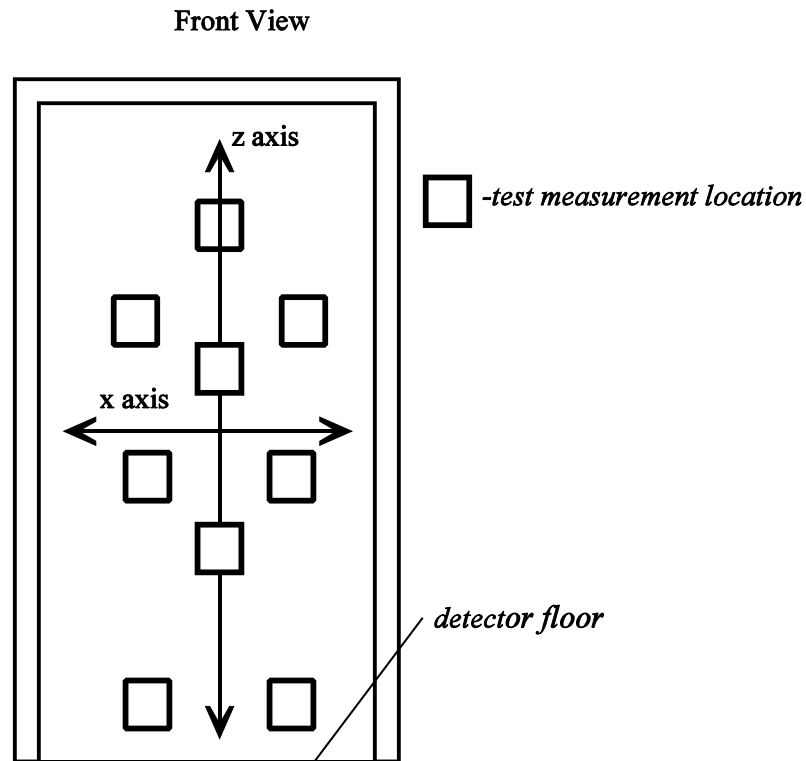
*Test objects* used to test the discrimination performance of the *large object size* and *medium object size* walk-through metal detectors. Mechanical drawings of the *innocuous item test objects* are provided in section 5.3.

### 1.2.17 Test Object Axes

The three mutually orthogonal axes of the *test object* that are referenced to and have a one-to-one correspondence to the axes of a *measurement coordinate system*.

### 1.2.18 Test Measurement Location

The positions in the x-z plane (which is parallel to the *detector plane*) through which the *test object(s)* shall be passed. The *test measurement locations* are based on the size of the average male person and are defined at points along the x and z axes of the *measurement coordinate system*. There are two locations at ankle height separated approximately by hip width, two at hip height separated approximately by hip width, two at shoulder height separated approximately by



*Figure 3. Diagram illustrating the nine test measurement locations positioned in relation to the x and z axes of the measurement coordinate system*

torso width, one at top of head height centered along the z axis, one at slightly below armpit height centered along the z axis, and one at crotch height centered along the z axis. See figure 3.

### **1.2.19 Three-Axes Positioning System**

Also known as a Cartesian robot, the *three-axes positioning system* provides three mutually orthogonal directions of linear translation. The *three-axes positioning system* is used to place the magnetic field sensor (see sec.3.2) and *test objects* in the magnetic field of the detector.

## **2. REQUIREMENTS FOR ACCEPTANCE**

The detector shall meet the requirements and specifications stated in this section. Reports shall be provided on the forms contained in section 6.

### **2.1 Safety Specifications and Requirements**

#### **2.1.1 Electrical**

The detector shall comply with UL 1950, Second Edition, Underwriters Laboratories Standard for Information Technology Equipment, Including Electrical Business Equipment, if the electrical potential difference between any two points within the detector is greater than 30 V rms (42.4 V peak) for alternating-currents (ac) or greater than 60 V referenced to ground for direct-currents (dc).

#### **2.1.2 Mechanical**

The detector shall not expose (1) any sharp corners or edges that can puncture, cut, or tear the skin or clothing or injure persons coming in contact with the detector, (2) external wires and cables except the ac connector described in section 2.2.1.1, or (3) loose covers and cowlings. The minimum exposed radius of curvature for corners and edges shall be 2 mm (0.08 in).

#### **2.1.3 Exposure**

The level of the magnetic field generated by the detector shall be less than the exposure limits specified in ACGIH-0302 (1996), Sub-Radio Frequency (30 kHz and below) Magnetic Fields, as amended.

#### **2.1.4 Exposure Warning Labels**

A warning label which states, "This Device May Affect Personal Medical Electronic Devices," shall be permanently affixed to the detector to warn operators and persons subject to screening of potential danger of exposure to magnetic fields until such time that the Food and

Drug Administration or some other competent Federal agency requires a different warning label or has determined that no such warning is necessary.

## **2.2 Electrical Requirements**

### **2.2.1 AC Power**

The detector shall operate at power line voltages of 105 V to 129 V at 58 Hz to 62 Hz and shall be tested in accordance with section 3.8. The manufacturer shall provide a visual indicator to alert the operator of the ac power status, if low, as described in section 2.6.2.2.

#### **2.2.1.1 AC Connector**

An ac power connector socket shall be provided on both sides of the detector portal unless the operation and function of the detector is the same for traffic flow in both directions, in which case an ac connector is required on one side of the portal. The ac connector socket should be recessed and provide a secure connection.

#### **2.2.1.2 Surge Protection**

The detector shall have practical electrical surge immunity as described in IEEE C62.41–1991 and tested in accordance with the procedures described in IEEE C62.45–1987.

### **2.2.2 Burn-In**

Power-on dynamic burn-in testing, at the manufacturer's or contractor's plant, is required in accordance with section 3.7.

### **2.2.3 EEPROM Program Storage**

The detector shall have either an electrically erasable and programmable read-only memory (EEPROM) device in the event of loss or disruption of ac power to maintain the calibration and set-up of the walk-through metal detector parameters.

## **2.3 Detection Performance Specifications**

### **2.3.1 Detection Sensitivity**

The *detector response* shall be measured for each *test object* of the appropriate *object size class* for each allowed orientation of the *test object axes* with respect to the *measurement coordinate system* moving at a speed of 1.0 m/s  $\pm$  0.05 m/s in accordance with section 3.2.3. The results shall be recorded and a report shall be provided. The *test object*, the orientation of the *test object axes* of this *test object* with respect to the *measurement coordinate system*, and the *test*

*measurement location* (see fig. 4) of this *test object* that provide a minimum *detector response* for the appropriate *object size class* shall be recorded and specified as the “minimum detection conditions.” The *test object*, the orientation of the *test object axes* of this *test object* with respect to the *measurement coordinate system*, and the *test measurement location* of this *test object* that provide a maximum *detector response* for the appropriate *object size class* shall be recorded and specified as the “maximum detection conditions.”

### **2.3.2 Speed**

The detector shall alarm for the “minimum detection conditions” for each appropriate *object size class* as determined according to section 2.3.1 for the *test object* moving at the following speeds: 0.2 m/s  $\pm$  0.01 m/s, 0.5 m/s  $\pm$  0.01 m/s, 1.0 m/s  $\pm$  0.01 m/s, 1.5 m/s  $\pm$  0.01 m/s, and 2.0 m/s  $\pm$  0.01 m/s as tested in accordance with section 3.2.4. The results shall be recorded.

### **2.3.3 Repeatability**

The detector shall alarm without failure for the “minimum detection conditions” for each appropriate *object size class* as determined according to section 2.3.1 for the *test object* moving at a speed of 1.0 m/s  $\pm$  0.05 m/s for 50 consecutive trials under the following conditions:

- a) The delay between subsequent trials shall be no more than 60 s.
- a) There shall be no detector readjustment between trials.

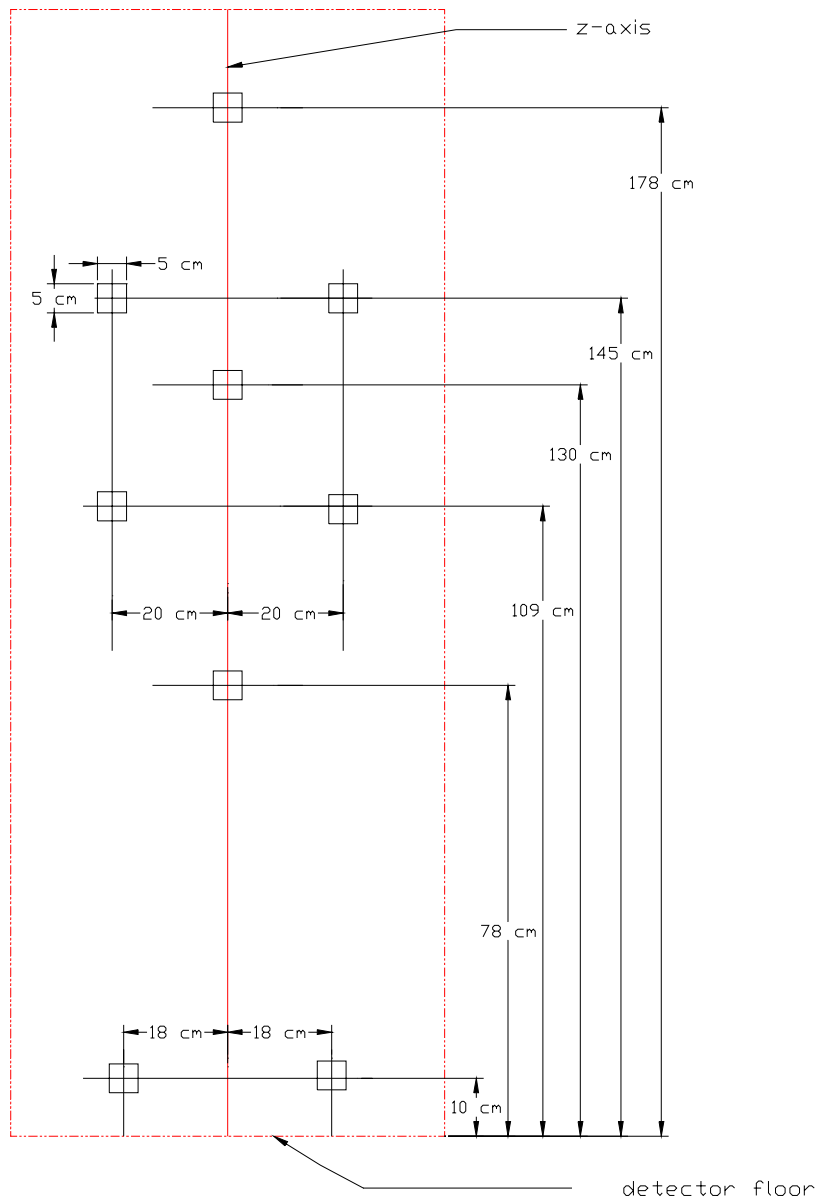
The repeatability test shall be performed in accordance with section 3.2.4 and the results shall be recorded.

### **2.3.4 Discrimination**

#### **2.3.4.1 Large Object Size**

The detector shall alarm for the “minimum detection conditions” for each appropriate *object size class* as determined according to section 2.3.1 for the *test object* moving at a speed of 1.0 m/s  $\pm$  0.05 m/s and without detector readjustment shall not alarm for the applicable *innocuous item test object* (listed in sec. 5.3) for each *test measurement location* moving at a speed of 1.0 m/s  $\pm$  0.05 m/s for 50 consecutive trials without failure under the following conditions:

- a) The *test object axes* shall be oriented to give the strongest interaction between the *test object* and the detector.
- b) The delay between subsequent trials shall be no more than 60 s.
- c) There shall be no detector readjustment between trials.
- d) Tests shall randomly alternate between *innocuous item test object* and appropriate *object size class test object*.



tolerance on all dimensions is  $\pm 2.5$  cm

**Figure 4. Test measurement locations for detection performance tests where the boxes represent the acceptable uncertainty ( $\pm 2.5$  cm) in the test measurement location and the broken line represents the inside dimensions of the walk-through metal detector**

The discrimination test shall be performed in accordance with section 3.2.4 and the results shall be recorded.

#### **2.3.4.2 Medium Object Size**

The detector shall alarm for the “minimum detection conditions” for each appropriate *object size class* as determined according to section 2.3.1 for the *test object* moving at a speed of  $1.0 \text{ m/s} \pm 0.05 \text{ m/s}$  and without detector readjustment shall not alarm for the applicable *innocuous item test object* (listed in sec. 5.3) for each *test measurement location* moving at a speed of  $1.0 \text{ m/s} \pm 0.05 \text{ m/s}$  for 50 consecutive trials without failure under the following conditions:

- a) The *test object axes* shall be oriented to give the strongest interaction between the *test object* and the detector.
- b) The delay between subsequent trials shall be no more than 60 s.
- a) There shall be no detector readjustment between trials.
- b) Tests shall randomly alternate between *innocuous item test object* and appropriate *object size class test object*.

The discrimination test shall be performed in accordance with section 3.2.4; the results shall be recorded and a report shall be provided.

#### **2.3.5 Body Concealment**

The detector shall alarm for each appropriate *test object* as tested in accordance with section 3.2.5; the results shall be recorded and a report provided.

#### **2.3.6 Throughput**

The maximum time interval between a *positive alarm indication* for the “minimum detection conditions” and the “maximum detection conditions,” as determined according to section 2.3.1 for the *test objects* moving at a speed of  $1.0 \text{ m/s} \pm 0.01 \text{ m/s}$ , shall be less than or equal to 1.2 s as tested in accordance with section 3.2.6, and the results shall be recorded.

#### **2.3.7 Multiple Metal Objects**

The detection of an electrically conductive or magnetizable object located arbitrarily within the portal shall not be affected by the presence of another electrically conductive and/or magnetizable object simultaneously present within the portal and located arbitrarily with respect to the first object.

## **2.4 Operating Requirements**

### **2.4.1 Operator Controls**

Only those controls required to operate the equipment shall be accessible to the operator. Other controls and adjustments that affect the detector performance shall be inaccessible to the operator. The detector shall be self-testing upon turn-on without any adjustment required by the operator and shall be continuously self-testing during the period of operation with automatic self-adjusting, if required. The following operator controls shall be provided:

#### **2.4.1.1 Power On/Off Switch**

The detector shall have a power on/off switch.

#### **2.4.1.2 Audio Alarm On/Off Switch**

The detector shall have an on/off switch for the audio alarm.

#### **2.4.1.3 Detector Reset Button**

The detector shall reset automatically to the set program parameters in the event of a detector or system failure or overload. If the automatic reset for a detector overload condition is not functioning properly, there shall be a detector reset button to reset the detector such that program parameters are not affected.

#### **2.4.1.4 Detector Sensitivity Programming**

If provided, the detector shall be programmed electronically and provide at least 16 discrete sensitivity settings where 1 of these settings shall correspond to *large object size* and a different setting shall correspond to *medium object size*. The switch shall be located such that it is readily accessible to the operator or, upon request, within an enclosed area inaccessible to the operator.

### **2.4.2 Control Panel Error Codes**

The detector shall display an error code that has the following two-digit error code format. The first digit represents the general area of system failure. The manufacturer may use the second digit (0,1,...9) to provide additional guidance to the technician servicing the detector. The following code shall be used as the first digit of the two-digit error code to indicate the general failure:

- “1” shall indicate a power circuitry malfunction.
- “2” shall indicate an alarm circuitry malfunction.
- “3” shall indicate an emitter circuitry malfunction.

“4” shall indicate a detection circuitry malfunction.

“5” shall indicate a signal processing circuitry malfunction.

### **2.4.3 Interference**

#### **2.4.3.1 Electromagnetic**

##### **2.4.3.1.1 Conducted**

###### **2.4.3.1.1.1 Emission**

The detector shall comply with FCC 47 CFR; Title 47–Telecommunications; Part 15, Radio Frequency Devices, as amended, if applicable.

###### **2.4.3.1.1.2 Susceptibility**

The detector shall not be affected by outside influences as tested in accordance with sections 12.1 and 12.2 of American Society for Testing and Materials (ASTM) Designation F 1468–95, as amended. The interference shall not cause the detector to alarm without cause or affect the equipment’s ability to detect as tested in accordance with section 3.2.

##### **2.4.3.1.2 Radiated**

###### **2.4.3.1.2.1. Emission**

The detector shall comply with FCC 47 CFR; Title 47–Telecommunications; Part 15, Radio Frequency Devices, as amended, if applicable.

###### **2.4.3.1.2.2 Susceptibility**

The detector shall not be affected by outside influences as tested in accordance with section 13 and section 14 of American Society for Testing and Materials (ASTM) Designation F1468–95, as amended. The interference shall not cause the detector to alarm without cause or affect the equipment’s ability to detect as tested in accordance with section 3.2.

#### **2.4.3.2 Metallic Interference**

##### **2.4.3.2.1 Stationary Objects, Metal Wall**

The detector shall produce a *positive alarm indication* to a *test object* when operated near a metal wall as tested in accordance with section 3.5.1.



#### **2.4.3.2.2 Stationary Objects, Steel Reinforced Floor**

The detector shall produce a *positive alarm indication* to a *test object* when operated near a steel reinforced floor as tested in accordance with section 3.5.2.

#### **2.4.3.2.3 Moving Objects, Moving Metal Door**

The detector shall not produce a *positive alarm indication* when operated near a moving metal door, as tested in accordance with section 3.5.3, but shall produce a *positive alarm indication* for each appropriate *test object* and its orientation providing a minimum response as determined according to section 2.3.2 for the *test object* moving at a speed of  $1.0 \text{ m/s} \pm 0.05 \text{ m/s}$  at each *test measurement location* when operated while such a door is moving in accordance with section 3.5.3.

### **2.4.4 Environmental Ranges and Conditions**

The detector or all of its components and their interconnections shall meet the requirements of all of the following standards. The requirements of section 2.1 and of section 2.5 shall not be affected by the tests described in this section. The requirements given in this section shall be applied appropriately for either indoor or indoor/outdoor detector models. The requirements of this section shall be exhibited by no less than the first production unit for each unique detector model and for any physical modifications to that model.

#### **2.4.4.1 Temperature Stability and Range**

##### **2.4.4.1.1 Indoor**

The detector shall operate over the temperature range of at least 0 °C to 43 °C (32 °F to 109 °F) with no observable change in detection performance specifications.

##### **2.4.4.1.2 Indoor/Outdoor**

The detector shall operate over the ambient temperature range of at least -37 °C to 65 °C (-35 °F to 149 °F) with no observable change in detection performance specifications.

#### **2.4.4.2 Relative Humidity Stability and Range**

##### **2.4.4.2.1 Indoor**

The detector shall be tested in accordance with the requirements of MIL-STD-810E Method 507.3, Procedure I - Natural, as amended, with no observable change in detection performance specifications.

#### **2.4.4.2.2 Indoor/Outdoor**

The detector shall be tested in accordance with the requirements of MIL–STD–810E Method 507.3, Procedure I - Natural, as amended, with no observable change in detection performance specifications.

#### **2.4.4.3 Salt Fog**

##### **2.4.4.3.1 Indoor**

Not applicable.

##### **2.4.4.3.2 Indoor/Outdoor**

The detector shall be tested in accordance with the requirements of MIL–STD–810E Method 509.3, as amended, with no observable change in detection performance specifications.

#### **2.4.4.4 Fungus**

##### **2.4.4.4.1 Indoor**

Not applicable.

##### **2.4.4.4.2 Indoor/Outdoor**

The detector shall be tested in accordance with the requirements of MIL–STD–810E Method 508.4, as amended, with no observable change in detection performance specifications.

#### **2.4.4.5 Rain**

##### **2.4.4.5.1 Indoor**

Not applicable.

##### **2.4.4.5.2 Indoor/Outdoor**

The detector shall be tested in accordance with and meet the requirements of MIL–STD–810E Method 506.3, as amended, with no observable change in detection performance specifications.

#### **2.4.4.6 Sand/Dust**

##### **2.4.4.6.1 Indoor**

The detector shall be tested in accordance with and meet the requirements of MIL–STD–810E Method 510.3, as amended, with no observable change in detection performance specifications.

##### **2.4.4.6.2 Indoor/Outdoor**

The detector shall be tested in accordance with and meet the requirements of MIL–STD–810E Method 510.3, as amended, with no observable change in detection performance specifications.

#### **2.4.4.7 Environmental Corrosion**

##### **2.4.4.7.1 Indoor**

Not applicable.

##### **2.4.4.7.2 Indoor/Outdoor**

The detector enclosure shall meet the requirements of NEMA 250–1997, Section 3 for Enclosure Type 4, as amended, with no observable change in detection performance specifications.

#### **2.4.4.8 Solar Radiation (Sunshine)**

##### **2.4.4.8.1 Indoor**

Not applicable.

##### **2.4.4.8.2 Indoor/Outdoor**

The detector shall be tested in accordance with and meet the requirements of MIL–STD–810E Method 505.3, as amended, with no observable change in detection performance specifications.

### **2.5 Mechanical Specifications and Requirements**

#### **2.5.1 Dimensions and Weight**

The detector shall be designed so the interior of the portal through which people will walk has the following dimensions:

- a) Height, minimum: 195 cm (78 in).

- b) Width, minimum: 71 cm (28 in) unless required to comply with that specified by the American Disabilities Act.
- c) Depth, maximum: 91 cm (36 in).

The detector shall be light enough and designed to be relocated with a minimum expenditure of effort by two persons and shall have a mass of less than 100 kg (220 lb).

## **2.5.2 Durability/Ruggedness**

The detector or all of its components and their interconnections shall meet the requirements of the following standards. The requirements of section 2.1 and of section 2.5 shall not be affected by the tests described in this section.

### **2.5.2.1 Impact Resistance**

#### **2.5.2.1.1 Shock**

The detector shall be tested in accordance with the requirements of IEC 68–2–27 1987, as amended, with no observable change in detection performance specifications.

#### **2.5.2.1.2 Bump**

The detector shall be tested in accordance with the requirements of IEC 68–2–29 1987, as amended, with no observable change in detection performance specifications.

#### **2.5.2.1.3 Drop and Topple**

The detector shall be tested in accordance with the requirements of IEC 68–2–31 1982, as amended, with no observable change in detection performance specifications.

#### **2.5.2.1.4 Free Fall**

The detector shall be tested in accordance with the requirements of IEC 68–2–32 1975, as amended, with no observable change in detection performance specifications.

#### **2.5.2.1.5 Bounce**

The detector shall be tested in accordance with the requirements of IEC 68–2–55 1987, as amended, with no observable change in detection performance specifications.

### **2.5.2.2 Pressure Resistance**

The detector should be capable of being secured in place to prevent being tipped over or slipping as a result of casual bumping. The detector shall be capable of withstanding the forces described below.

#### **2.5.2.2.1 Slide**

A force shall be applied at or near the middle of the detector in the direction of search passage until the detector starts to slide. The detector shall be capable of withstanding the force of 200 N (45 lb) without sliding.

#### **2.5.2.2.2 Tip-Over**

The detector shall be tested in accordance with section 5.4 of American Society for Testing and Materials (ASTM) Designation F 1468–95, as amended. The test results shall be recorded and a report provided. The detector shall be capable of withstanding the force of 600 N (135 lb) without tipping.

## **2.6 Functional Requirements**

### **2.6.1 Audible Alarms**

All audible indicators (other than an earphone) shall produce an alarm-state sound pressure level  $0.8 \text{ m} \pm 0.08 \text{ m}$  from the detector of  $85 \text{ dB}_{\text{SPL}} \pm 5 \text{ dB}_{\text{SPL}}$  measured in accordance with section 3.3.2. For status indicators, the audible alarm shall be a two-state audible alarm and the two states shall be active (alarm state) and inactive (nonalarm state). The two-state alarm indicator shall produce no sound in the nonalarm state.

#### **2.6.1.1 Earphone Jack, Optional**

If an earphone jack is supplied with the walk-through metal detector, the earphone shall disable the audible *alarm indicator* when the earphone is plugged into the earphone jack.

#### **2.6.1.2 Metal Object Detection**

The detector shall have a two-state audible alarm which shall alarm to indicate the presence of a *test object* in the portal region.

### **2.6.1.3 AC Low Power Condition**

The detector shall have a two-state audible alarm to indicate the ac power level is out of specification and shall be activated if the state of the ac power changes to a level that can cause an observable change in detection performance specifications.

### **2.6.1.4 System Status**

The detector shall have a two-state audible alarm to indicate the operational state of the detector system and shall alarm if there exists a system status problem.

### **2.6.1.5 Pass-Through Speed Range Violation**

The detector shall have a two-state audible alarm to indicate if a person passes through the detector at a speed outside the test speed range stated in section 2.3.2 and shall be activated if the speed range is violated or the detector performance is changed.

### **2.6.1.6 Detection Ready State Violation**

The detector shall have a two-state audible alarm to indicate whether any person has passed through the detector when it was not in the ready state as described in section 2.6.2.8 and shall be activated if a person attempts to pass through the detector when it is not in the ready state.

## **2.6.2 Visual Indicators**

Any visible *alarm indication* shall be readily perceptible when tested in accordance with section 3.3.3. The visual *alarm indicators* shall be a two-state visual alarm and the two states shall be active (illuminating) and inactive (nonilluminating).

### **2.6.2.1 Metal Object Detection**

The detector shall have a visual alarm indicating the presence of a metal object in the portal area. The alarm state for the metal-object-detection visual *alarm indicator* shall be active (illuminating) and the nonalarm state shall be inactive (nonilluminating). The metal-object-detection visual *alarm indicator* shall be distinct from any other visual *alarm indicators*.

### **2.6.2.2 AC Power Condition**

The detector shall have a visual alarm indicating the condition of the ac power and shall be activated if the power condition changes to a level that can cause a degradation of the detection performance required by this standard. The power-condition visual *alarm indicator* shall be active (illuminating) if the power condition is acceptable and shall be inactive (nonilluminating)

if there exists a power condition problem. The power-condition visual *alarm indicator* shall be distinct from any other visual *alarm indicators*.

### **2.6.2.3 System Status**

The detector shall have a visible alarm indicating the operational state of the system and shall be activated if the operational state of the detector can cause a degradation of the detection performance required by this standard. The system status visual *alarm indicator* shall be inactive (nonilluminating) if the system status is acceptable and shall be active (illuminating) if there exists a system status problem. The system status visual *alarm indicator* shall be distinct from any other visual *alarm indicators*.

### **2.6.2.4 Pass-Through Speed Range Violation**

The detector shall have a visible alarm to indicate if a person passes through the detector at a speed outside the test speed range stated in section 2.3.2 and the visual *alarm indicator* shall be active (illuminating) if the speed range is violated or the detector performance is changed by more than 5 % and shall be inactive (nonilluminating) otherwise.

### **2.6.2.5 Detection Ready State Violation**

The detector shall have a visible alarm to indicate whether any person has passed through the detector when it was not in the ready state as described in section 2.6.2.6 and the visual *alarm indicator* shall be activate (illuminating) if a person attempts to pass through the detector when it is not in the ready state, and inactive (nonilluminating) otherwise.

### **2.6.2.6 Detection Ready State (Stop/Go)**

The detector shall have, at the top of the archway and clearly visible to the approaching traffic, a visual indicator showing the ready state of the detector, that is, whether the detector is ready to allow a pass through or not. The ready state shall be have a green and red visual indicator; the green visual indicator shall denote readiness and the red visual indicator shall denote lack of readiness. The green light (or “Go” light) shall indicate that the detector is ready for a person to enter and pass through the detector and the red light (or “Stop” light) shall indicate that the detector is not ready for a person to enter the detector.

## **2.6.3 Detection Signal Output Connector**

The detector shall have a coaxial cable connector that provides an output of the detector signal and this detector signal shall be extracted immediately after the sensor circuitry on which an *alarm indication* is based but before the circuitry which executes the alarm. The outer conductor of the connector shall provide signal ground or return. For detectors consisting of more than one emitter and/or sensor, such as in multizone detectors, there shall be a *detection*

*signal output connector* for each sensor or sensor circuit unless the sensor or sensor circuit outputs are multiplexed together so that one *detection signal output connector* can be used to monitor the output of each sensor or sensor circuit.

#### **2.6.4 Interchangeability**

Any given model of detector manufactured by the same manufacturer shall have uniform interchangeable components including the following:

- a) Replacement parts.
- b) Error codes.
- c) Program codes.
- d) Diagnostic warnings.

#### **2.6.5 Field Servicing**

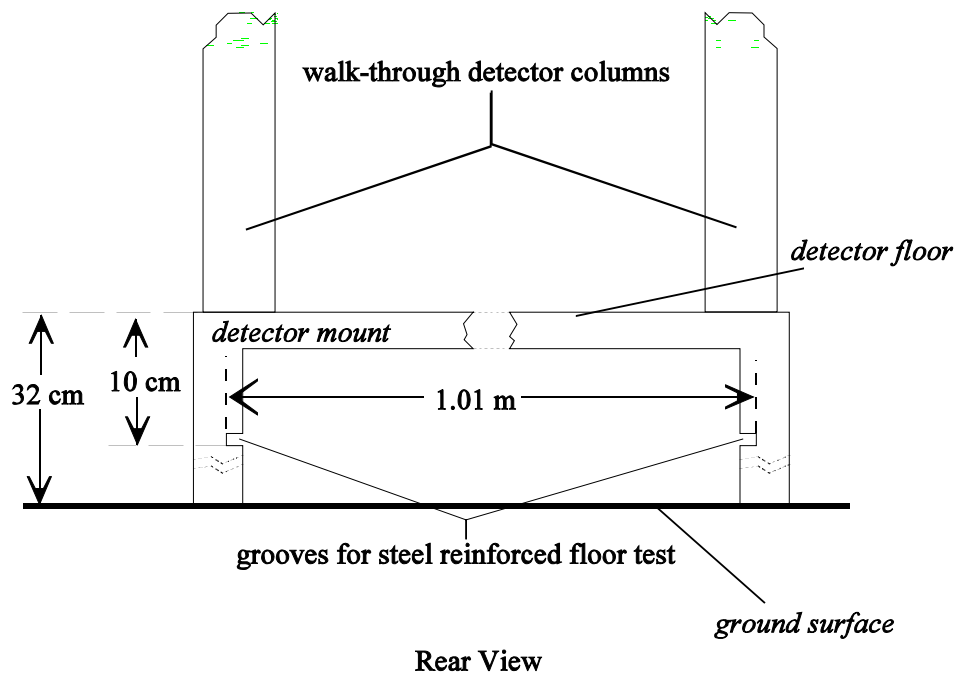
The detector shall be designed for ease of maintenance, that is, to clean, inspect, adjust, align, and repair the detector. The electronics shall be of modular design and easily accessible for maintenance and repair.

#### **2.7 Detector Mount**

The manufacturer shall provide with each detector, if requested, a *detector mount* for positioning the walk-through metal detector for performance tests. See figure 2. The *detector mount* (see fig. 5) shall comply with the requirements of section 2.1.2 and shall meet the following specifications:

- a) Relative permeability =  $1. \pm 0.001$ .
- b) Electrical conductivity  $< 10^{-8}$  Siemens/m.
- c) Mass 50 kg (110 lb).
- d) Flatness of surface mating to *reference surface*  $\pm 0.5$  mm (0.041 in).
- e) Hold the detector in position.
- f) Mate with the *reference surface* (see fig. 6).
- g) Fastener holes that align with each of the (two to four) 3/8-16 fastener holes of the *reference surface* (see fig. 6).
- h) Hold the detector so that the *detector plane* and the x-z plane of the *measurement coordinate system* are parallel to within  $\pm 1$  degree.
- i) Hold the detector so that the *detector plane* is  $0.5 \text{ m} \pm 0.01 \text{ m}$  from the *reference surface* (see fig. 2 and 6).
- j) Position the *detector floor* at a height of  $32 \text{ cm} \pm 1 \text{ cm}$  above the *ground surface* (see fig. 5).
- k) Provide a  $1 \text{ cm} \pm 0.1 \text{ cm}$  groove for the steel reinforced floor test panel at a height of  $5 \text{ cm} \pm 0.5 \text{ cm}$  above the *ground surface* (see fig. 5).





*Figure 5. Drawing of the detector mount showing the positioning of grooves for the steel reinforced floor test*

## 2.8 Quality Control and Assurance

The manufacturer shall meet the requirements of ISO 9001:1994(E), as amended.

## 2.9 Documentation

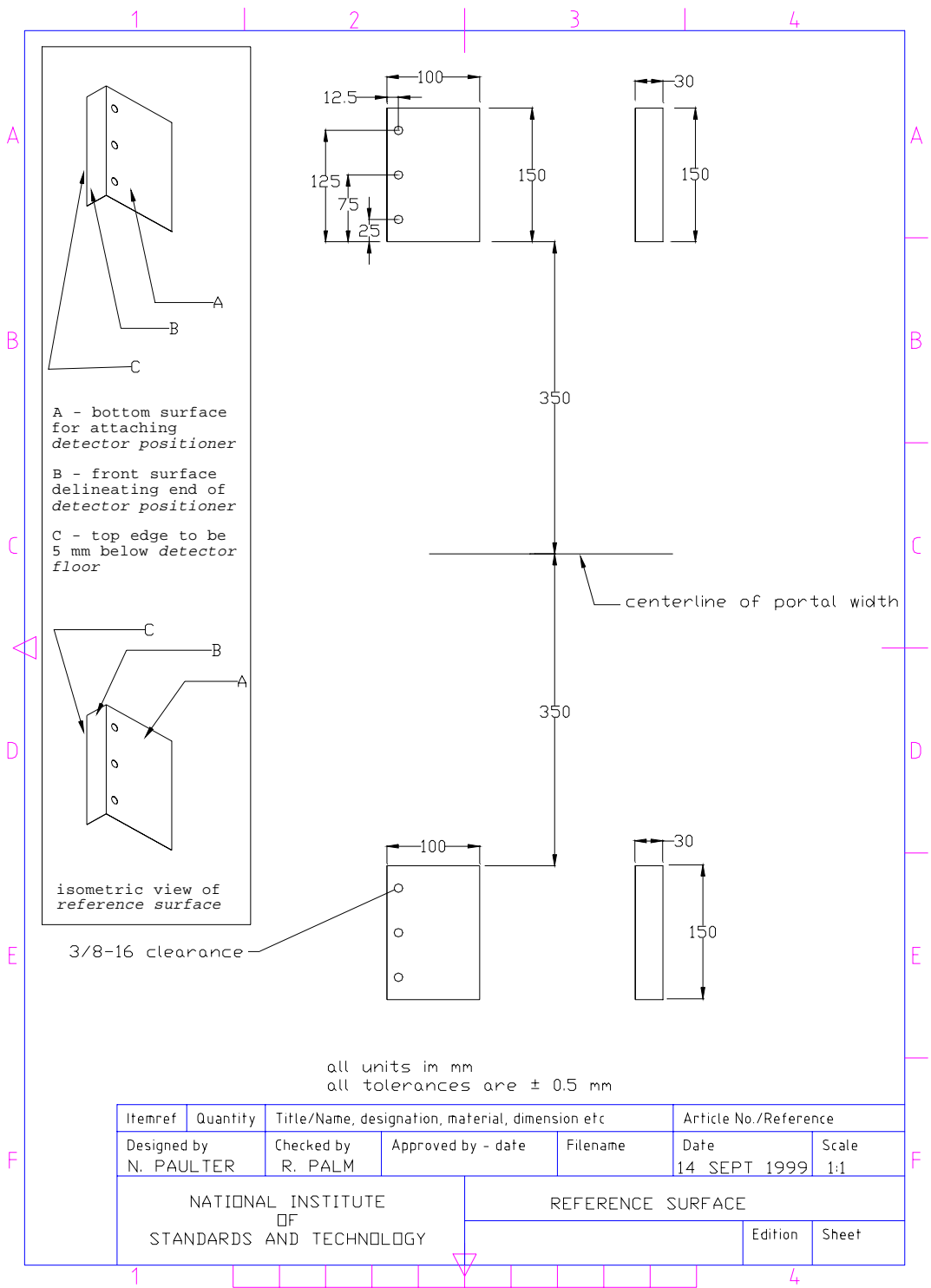
The manufacturer shall provide the following list of deliverable items with each detector.

### 2.9.1 Operating Instructions

An operator's manual shall be supplied by the manufacturer or distributor with each detector.

#### 2.9.1.1 Discussion of Operation

The manufacturer shall provide a manual designed to ensure that the operators will have the knowledge and skill to understand the purpose, detection principles, and detection capabilities of the detector. The manual shall identify the main components of the detector, the features of the controls, and specify the electromagnetic emissions of the detector.



**Figure 6. Mechanical drawing of the reference surface**

### **2.9.1.2 Block Diagram of Major Internal Components**

The manufacturer shall provide a drawing of the configuration and specifications of the detector (Block Diagram) to assist in trouble-shooting and servicing of the detector.

### **2.9.2 Operator Training Instructions and Videotape or CD-ROM**

A training package shall be supplied that will provide operators with the information necessary to acquire the technical and operational skills required to conduct effective screening with the detector. The training package shall include an audio/visual videotape or CD-ROM as well as an operator's manual. For additional guidance in formulating the operator training package, review ASTM Designation F 1532-94, "Standard Guide for Qualification, Selection, Training, Utilization, and Supervision of Security Screening Personnel," published by the American Society for Testing and Materials; or "A Users' Guide for Hand-Held and Walk-Through Metal Weapon Detectors," published by the National Institute of Justice. The manufacturer shall have demonstrated the effectiveness of the training material when 50 % of the test group receiving the training understands the operation of the detector and passes a written test and can operate the detector successfully as judged by performing the field tests of section 4 without supervision, where the test group consists of at least 10 people with only a high school education.

### **2.9.3 Technical Manual**

A technical manual shall be provided upon request which contains all of the information that could be required by a technician to troubleshoot, maintain, and repair the equipment to the component level.

### **2.9.4 Technical Training Manual and Videotape or CD-ROM**

A self-study training package shall be provided for use by site maintenance technicians, upon request. The training package must consist of an audio/visual videotape or CD-ROM as well as a technical manual that provides detailed explanations of circuit theory and maintenance procedures.

### **2.9.5 Technical Specifications**

The manufacturer shall provide a detailed listing of all relevant specifications of the detector. This checklist shall include at a minimum:

- a) Detector *object size class* (as defined in sec. 1.3).
- b) Mechanical drawings of the detector with dimensions in metric units.
- c) Mass of the detector.
- d) Allowable range of ac line power supply voltage.

- e) Battery type, quantity, and life.
- f) Maximum magnetic field strength that can be found on the detector surface.
- g) If applicable, operating frequency and, if applicable, modulation parameters.
- h) If applicable, pulse repetition rate, pulse duration, and pulse transition duration.
- i) Operating ambient temperature range.

### **2.9.6 Certification of Inspection and Conformance**

The manufacturer shall provide a certification of all mandatory tests, a record of the test results for the detector, and the identity of the organization(s) conducting the tests.

### **2.9.7 Certification of Test Procedures**

The manufacturer shall provide a detailed step-by-step description of the test plan and procedures. The manufacturer shall provide a certification with each delivered detector showing that a set of  $m$  detectors of the same type and model as the delivered detector were selected using simple random sampling methods and tested without replacement (where  $m = \frac{0.1Mk_M}{0.1k_M + 0.01M}$ ,

$M$  is the number of available detectors and  $k_M$  is the coverage factor for the 99 % confidence interval, see table B.1 of B.N. Taylor and C.E. Kuyatt, “NIST Technical Note 1297, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results,” U.S. Government Printing Office, Washington, DC, 1994), and met the requirements of this standard. The manufacturer shall provide the test results of this randomly selected set of same type and model detectors.

### **2.9.8 Suggested Maintenance Schedule**

The manufacturer shall provide a preventive maintenance schedule and a detailed list of the technical skills, computer hardware, and software tools required.

### **2.9.9 Installation Instructions**

The manufacturer shall provide detailed instructions for the location and installation of the walk-through metal detector. The manufacturer shall also provide instructions for battery installation and specify the type and quantity of batteries required.

### **2.9.10 Report Sheets**

The manufacturer shall provide the completed report sheets contained in section 6 in accordance with the formats described therein.

### 3. PERFORMANCE TESTING PROCEDURES

The detector shall meet the detection performance requirements for each *object size class* in which it is required to operate. The detection performance shall be evaluated by the test methods described in this section. The manufacturer shall record and provide the test results on the Report Sheets provided in section 6 of this randomly selected set of same type and model detectors.

#### 3.1 General Test Conditions

##### 3.1.1 Test Location

The distance between any metal object other than a *test object* and the closest part of the detector shall be greater than 0.8 m (31 in).

##### 3.1.2 Environment

At the time of the tests, the ambient temperature shall be between -37 °C and 49 °C (-35 °F and 120 °F); the relative humidity shall be noncondensing and between 10 % and 80 %.

##### 3.1.3 Preparations

The walk-through metal detector shall be installed according to the manufacturer's instructions. Any setup or calibration adjustments specified in the operator's manual shall be performed if required.

#### 3.2 Detection Performance Tests

For walk-through metal detectors that contain more than one emitter and/or sensor, the *detector response* shall be recorded for each emitter or sensor appropriate for the location of the *test object* within the portal region of the detector and for the operation of the detector.

##### 3.2.1 Object Size Classes

If the detector can be adjusted to provide an *alarm indication* for both *large object size* and *medium object size*, the detection performance test shall be performed for each *object size class*. The detection performance shall be evaluated by the test methods described in this section.

##### 3.2.2 Equipment

###### 3.2.2.1 Test Objects

*Test objects* shall be as described in section 5.

### 3.2.2.2 Three-Axes Positioning System

The *three-axes positioning system* shall meet the following requirements:

- a) Displacement, x and y axes: 1 m.
- b) Displacement, z axis: 2 m.
- c) Position accuracy, each axis: 1 mm.
- d) Position repeatability, each axis: 1 mm.
- e) Maximum slew speed, y axis 2 m/s.

### 3.2.2.3 Magnetic Field Sensor

The magnetic field sensor shall have a frequency response bandwidth at least five times greater than the bandwidth of the emitted magnetic field, provide a rms voltage output, and have dimensions less than or equal to 4 cm x 4 cm x 4 cm.

### 3.2.2.4 Voltmeter

The ac voltmeter shall have a bandwidth at least five times greater than the bandwidth of the emitted magnetic field, allow computer control and data retrieval, and have a variable gain input with at least 10-bit resolution full scale.

### 3.2.2.5 Detector Positioner

The *detector positioner* is a nonconductive, nonmagnetic device that provides a *reference surface* on which to securely attach the *detector mount* and that maintains the *detector plane* at a fixed location in the *measurement coordinate system* relative to the *three-axes positioning system*. A detailed mechanical drawing of the *reference surface* is provided in fig. 6.

### 3.2.2.6 Computer Controller

The computer controller shall have installed and operational all necessary hardware and software for providing instrument control and data acquisition.

## 3.2.3 Detection Sensitivity

### 3.2.3.1 Initial Procedures

Ensure that the voltmeter and *three-axes positioning system* are connected to the computer controller and that the detection signal output connector (see sec. 2.6.3) is connected to the voltmeter. Turn on the voltmeter, computer controller, and positioning system and verify proper operation of the measurement system. Ensure that the walk-through metal detector is securely located and positioned in the *measurement coordinate system*. Attach the *test object* with the

proper orientation to the positioning system. Turn on the walk-through metal detector and ensure that its output functions properly by noting a change in the voltmeter reading as a metal object is brought near the detector. Ensure that the *test object* does not hit any objects while in motion.

### **3.2.3.2 Performing the Measurement**

Set the computer program to perform a 1-m-long y-axis scan at the specified speed that is perpendicular to, passes through, and is centered at the *detector plane* at the specified speed. Set the x-axis and z-axis positions to an extreme edge of the *detector plane* and scan the y-axis. Acquire the signal present at the detection signal output connector (see sec. 2.6.3) using the voltmeter and record this measurement as the y-axis is scanned. Move the x axis in  $2\text{ cm} \pm 0.1\text{ cm}$  increments and repeat the y axis scan for each x-axis increment until the end of the *detector plane* is reached. Move the z axis in  $2\text{ cm} \pm 0.1\text{ cm}$  increments while repeating the x-axis incremented motion with y axis scans until completed. Record the maximum and average detection signal value for each y-axis scan and report these values. The center for both the x and z direction scans shall be the *detector axis*, the x axis scan shall be  $5\text{ cm} \pm 0.5\text{ cm}$  less than the width of the portal, and the z-axis scan shall be  $5\text{ cm} \pm 0.5\text{ cm}$  less than the height of the portal.

### **3.2.4 Speed**

#### **3.2.4.1 Initial Procedures**

Ensure that the voltmeter and *three-axes positioning system* are connected to the computer controller and that the detection signal output connector (see sec. 2.6.3) is connected to the voltmeter. Turn on the voltmeter, computer controller, and *three-axes positioning system* and verify proper operation of the measurement system. Ensure that the walk-through metal detector is securely located and positioned within the *measurement coordinate system*. Adjust the detector to the appropriate sensitivity setting. Attach the *test object* with the proper orientation to the *three-axes positioning system*. Turn on the walk-through metal detector and ensure that its output functions properly by noting a change in the voltmeter reading as a metal object is brought near the portal region. Ensure that the *test object* does not hit any objects while in motion.

#### **3.2.4.2 Performing the Measurement**

Set the computer program to perform a 1-m-long y-axis scan at the specified speed that is perpendicular to, passes through, and is centered at the *detector plane* at the specified x-axis and z-axis position at the specified speed.

### 3.2.5 Body Concealment

#### 3.2.5.1 Initial Procedures

Select a *clean tester* to hold the appropriate *test object*. Ensure that the voltmeter is connected to the computer controller and the detection signal output connector (see sec. 2.6.3) is connected to the voltmeter. Turn on the voltmeter and computer controller and verify proper operation of the measurement system. Adjust the detector to the appropriate sensitivity setting. Ensure that the *clean tester* does not cause an *alarm indication* when walking through the detector portal.

#### 3.2.5.2 Performing the Measurement

Place each appropriate *test object* under the armpit of the *clean tester* in the most concealing orientation. Direct the tester to walk through the detector portal. Note the *alarm indication*.

### 3.2.6 Throughput

#### 3.2.6.1 Initial Procedures

Ensure that the voltmeter and *three-axes positioning system* are connected to the computer controller and that the detector detection signal output connector (see sec. 2.6.3) is connected to the voltmeter. Turn on the voltmeter, computer controller, and *three-axes positioning system* and verify proper operation of the measurement system. Ensure that the walk-through metal detector is securely located and positioned within the *measurement coordinate system*. Adjust the detector to the appropriate sensitivity setting. Attach the appropriate *test object* with the proper orientation to the *three-axes positioning system*. Turn on the walk-through metal detector and ensure that the detector output functions properly by noting a change in the voltmeter reading as a metal object is brought near the portal region of the walk-through metal detector. Ensure that the *test object* does not hit any objects while in motion.

#### 3.2.6.2 Performing the Measurement

Set the computer program to perform a 1-m-long y-axis scan at the specified measurement conditions. Record the response waveform of the walk-through detector for the “maximum detection conditions” as determined according to section 2.3.2, store the waveform data on the computer controller, label this waveform as  $W_0$ , and record the peak amplitude of  $W_0$  as  $V_0$ . The response waveform is obtained by acquiring 1000 voltmeter readings during the y-axis scan, one reading each millimeter. Record the response waveform for the “minimum detection conditions” as determined according to section 2.3.2, store the waveform data on the computer controller, label this waveform as  $W_1$ , and label the peak amplitude of  $W_1$  as  $V_1$ . For *large object size class* detectors, the “minimum detection conditions” are the same as the “maximum detection conditions.” Therefore, for *large object size class* detectors, set  $V_1 = V_0$ . Locate the time of



occurrence of  $V_0$  on  $W_0$  and label this time as  $t_0$ . Locate the time of occurrence of  $0.5 V_1$  on that part of  $W_0$  corresponding to the *test object* passing the *detector plane* and label this time as  $t_1$ . Subtract  $t_0$  from  $t_1$  and record and report this difference.

### **3.3 Alarm Indication Test**

#### **3.3.1 Equipment**

##### **3.3.1.1 Sound Level Meter**

The sound pressure level meter shall comply with ANSI S1.4, 1971, "Specifications for General Purpose Sound Level Meters," for type 3, A-weighting, reference pressure 20  $\mu$ Pa.

##### **3.3.1.2 Audio Frequency Measurement System**

The system for measuring the fundamental audio frequency of an audible alarm indication shall be capable of measuring a frequency difference with an accuracy of 1 Hz and be capable of providing a new measurement within 4 s after a change in frequency.

##### **3.3.1.3 Illumination Meter**

The illumination meter shall be capable of measuring light levels of 25  $\text{lm}/\text{m}^2$  and 10,000  $\text{lm}/\text{m}^2$  with an error of not more than 10 %. The integrated spectral response shall be within 10 % of the Commission Internationale de l'Eclairage (CIE, the International Commission on Illumination) photopic curve.

#### **3.3.2 Sound Pressure Level Test**

Perform the test in an anechoic chamber or at an outdoor location, at least 6 m (20 ft) from any large object, where the ambient sound pressure level at the time of the test is not more than 53  $\text{dB}_{\text{SPL}}$ . Position the sound pressure level meter microphone 0.80 m (31 in) from the detector. Measure the sound pressure level with the detector power applied and the *alarm indicator* in the nonalarm state. Then position the appropriate test object at a *test separation distance* of 5 cm (2 in) to produce an alarm, and again measure the sound pressure level.

#### **3.3.3 Visible Alarm Indicator Test**

Position the detector with its alarm indicator 0.80 m  $\pm$  0.05 m from the eyes, at a test site where the ambient illumination is 10,000 lux  $\pm$  1000 lux. After waiting at least 3 min to allow for eye accommodation, turn on the detector and move a metal object near the detector to cause an alarm. Observe the indication. Repeat the test at a test site where the ambient illumination is 25 lux  $\pm$  2.5 lux.

### **3.4 Test for Operation Near a Metal Wall, Steel Reinforced Floor, or Moving Metal Door**

#### **3.4.1 Metal Wall**

The effects of the proximity of a metal wall on the performance of the walk-through metal detector is assessed using a metal test panel.

##### **3.4.1.1 Metal Test Panel, Metal Wall**

The metal test panel shall be cold-finished sheet carbon steel AISI C1015 to C1020 with dimensions of  $1\text{ m} \pm 0.1\text{ m}$  by  $1\text{ m} \pm 0.1\text{ m}$  by  $0.75\text{ mm} \pm 0.13\text{ mm}$  and mounted in a nonelectrically conductive, nonmagnetizable frame to prevent bowing and bending of the metal test panel.

##### **3.4.1.2 Test Procedure**

Position the metal test panel such that its large surfaces are perpendicular to the *detector plane*, the x axis of the *measurement coordinate system* passes through the center of the metal test panel, and the x-axis separation between the metal test panel and the *detector axis* is  $2\text{ m} \pm 0.1\text{ m}$ . Move the test panel so that the x-axis separation between the metal test panel and the *detector axis* is  $1.5\text{ m} \pm 0.1\text{ m}$ . Note and record any alarm and, if necessary, adjust the program sensitivity until the alarm ceases. Test the detection sensitivity in accordance with section 3.2.4 using the test conditions specified in section 2.3.2 and using the appropriate *test object* that provides the minimum response according to section 2.3.2 and orient this *test object* such that it provides the smallest response as determined from section 2.3.2. Perform this test on both sides of the walk-through metal detector portal.

#### **3.4.2 Steel Reinforced Floor**

The effects of the proximity of a steel reinforced floor on the performance of the walk-through metal detector is assessed using a metal test panel.

##### **3.4.2.1 Metal Test Panel, Steel Reinforced Floor**

The test floor shall be cold-finished sheet carbon steel AISI C1015 to C1020 with dimensions of  $1\text{ m} \pm 0.01\text{ m}$  by  $1\text{ m} \pm 0.01\text{ m}$  by  $2\text{ mm} \pm 0.2\text{ mm}$ .

##### **3.4.2.2 Test Procedure**

Position the metal test panel such that it fits firmly in the grooves of the *detector mount* and is parallel with the *ground surface* (see fig. 7). Note and record any alarm and, if necessary, adjust the program sensitivity until the alarm ceases. Test detection sensitivity in accordance with section 3.2.4 using the test conditions specified in section 2.3.2 and using the appropriate

*test object* that provides the minimum response according to section 2.3.2 and orient this *test object* such that it provides the smallest response as determined from section 2.3.2.

### **3.4.3 Moving Metal Door**

The effects of the proximity of a moving metal door on the performance of the walk-through metal detector is simulated using a pivoting metal test panel.

#### **3.4.3.1 Metal Test Door**

The metal test door shall consist of a metal plate that shall be cold-finished sheet carbon steel AISI C1015 to C1020 with dimensions of  $2\text{ m} \pm 0.02\text{ m}$  by  $1\text{ m} \pm 0.02\text{ m}$  by  $2\text{ mm} \pm 0.2\text{ mm}$  attached with hinges to a stationary metallic frame such that the metal plate can swing 180 without obstruction.

#### **3.4.3.2 Test Procedure**

Position the metal test door such that the plane defined by the position of the metal plate at 0 and 180 is parallel to the *detector plane*, the *detector axis* is in the plane of the metal plate when the metal plate is in the 90 position, and the *detector plane* is 2 m from the metal plate at the 90 position. Place the metal plate at the 0 position. Rotate the metal plate to the 180 position in  $4\text{ s} \pm 1\text{ s}$  and record any alarms.

### **3.5 Burn-In Test**

The burn-in test is to be performed for a minimum of 160 consecutive hours, with the last 40 h failure free. The burn-in test shall include, at a minimum:

#### **3.5.1 Cycling of the Equipment**

Once each working shift (8 h), the detector shall be cycled on and off 10 times within 20 s and immediately (within 60 s) tested in accordance with section 2.3.4.

#### **3.5.2 Performance Evaluation**

Once each working shift (8 h), the detector shall be tested according to section 2.3.2 and section 2.3.5.

### **3.6 Power Line Voltage Test**

The detector shall be tested in accordance with the procedures of section 12, 12.1 Supply Voltage Variation, of American Society for Testing and Materials (ASTM) Designation F 1468–95, as amended.

## 4. FIELD TESTING PROCEDURES

### 4.1 Large Object Size

The detector shall be turned on and a *clean tester* should walk through the detector portal carrying each of the *innocuous item test objects* described in section 5.3 to assure that the objects are not detected. The *clean tester* should then walk through the detector portal carrying each of the *large object size test objects* described in section 5.1, one at a time, to assure that the objects are properly detected. Repeat this test three times at pass-through speeds ranging from approximately 0.5 m/s to approximately 1.5 m/s to assure proper detector performance.

### 4.2 Medium Object Size

The detector shall be turned on and a *clean tester* should walk through the detector portal carrying each of the *medium object size test objects* described in section 5.2, one at a time, to assure that the objects are properly detected. Repeat this test three times at pass-through speeds ranging from approximately 0.5 m/s to approximately 1.5 m/s to assure proper detector performance.

## 5. TEST OBJECTS DESCRIPTION

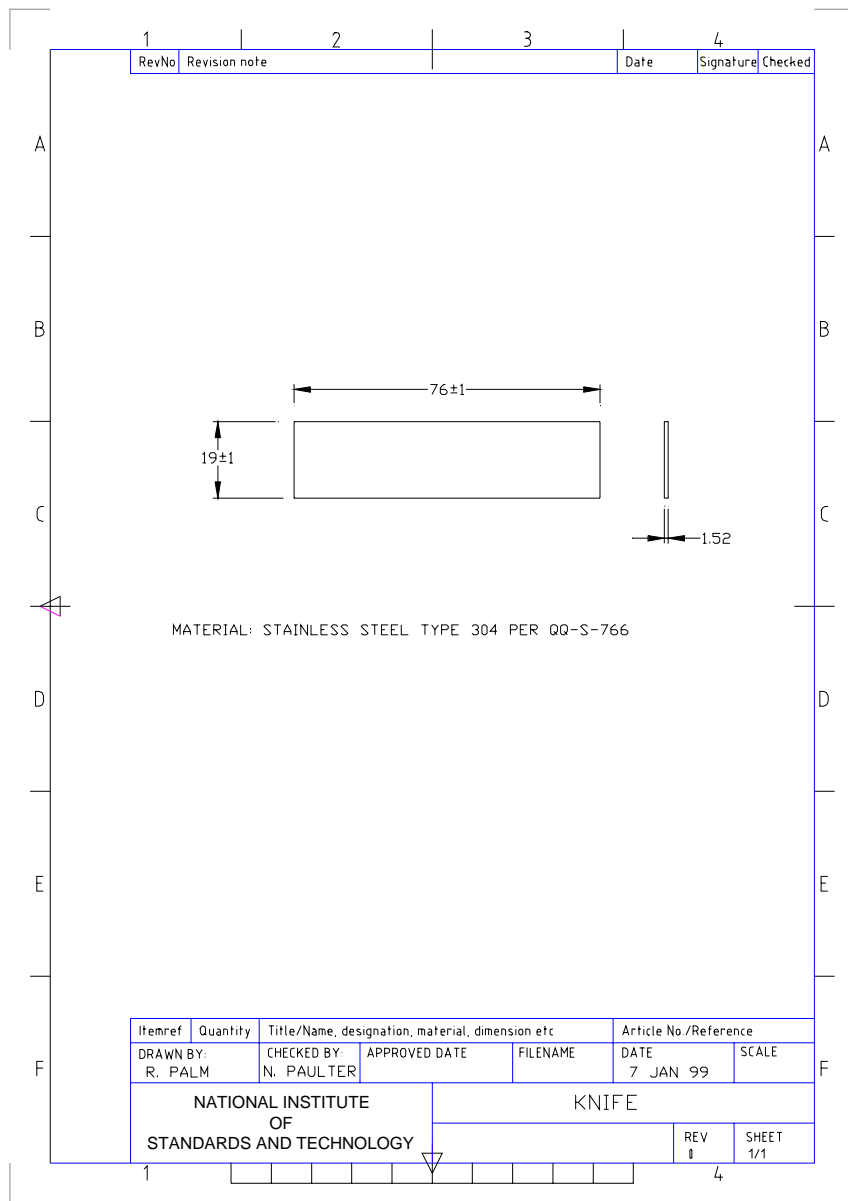
This section contains mechanical drawings of the *test objects*. The *test objects* are encased replicas of threat items. The dimensions in all the mechanical drawings of this section are in units of millimeters (mm).

### 5.1 Large Object Size Test Objects

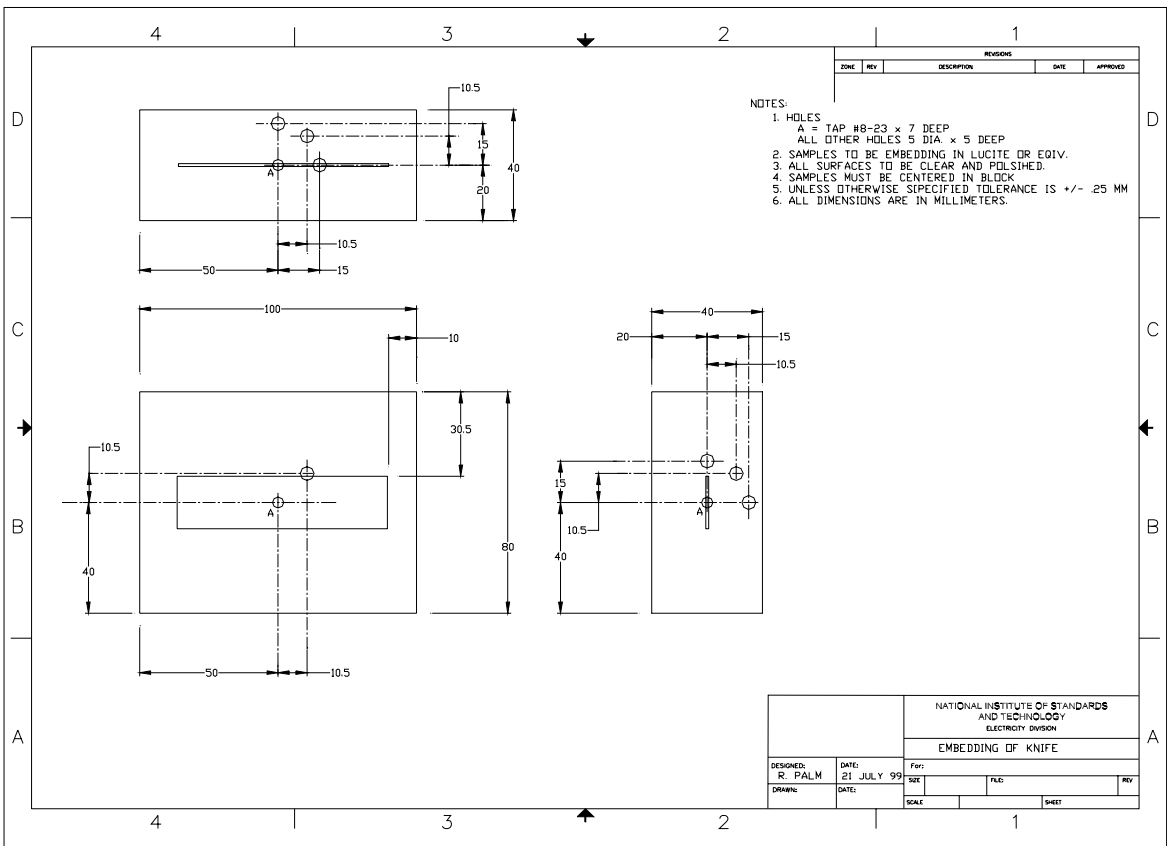
The following mechanical drawings are replicas of the *large object size* items considered a threat to officer, prisoner, inmate, and public safety. These *large object size* threat items are a knife and a handgun.

#### 5.1.1 Knife

This section contains the following mechanical drawings: the replica of a knife, a *large object size test object*; and the location of the *test object* within the encasement.

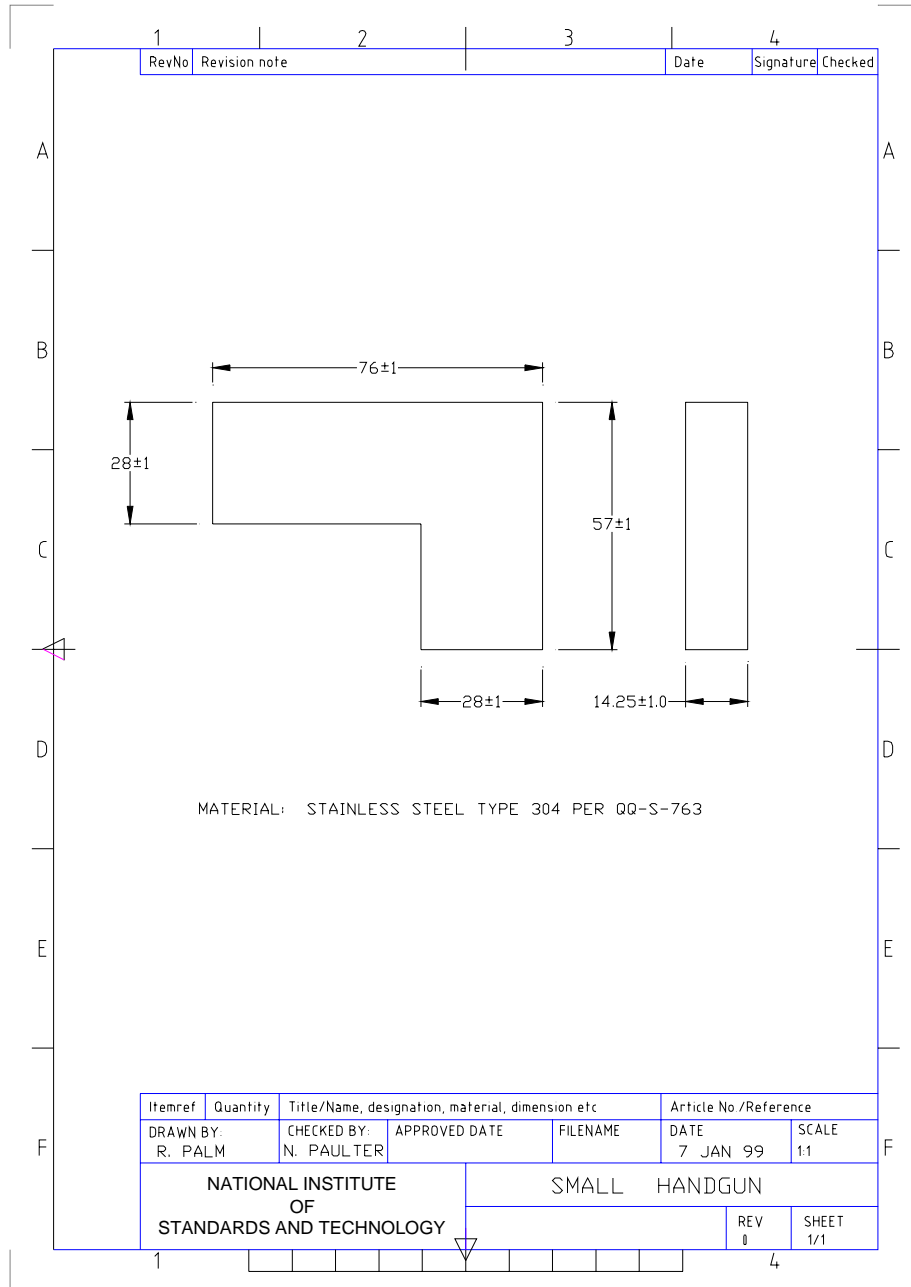


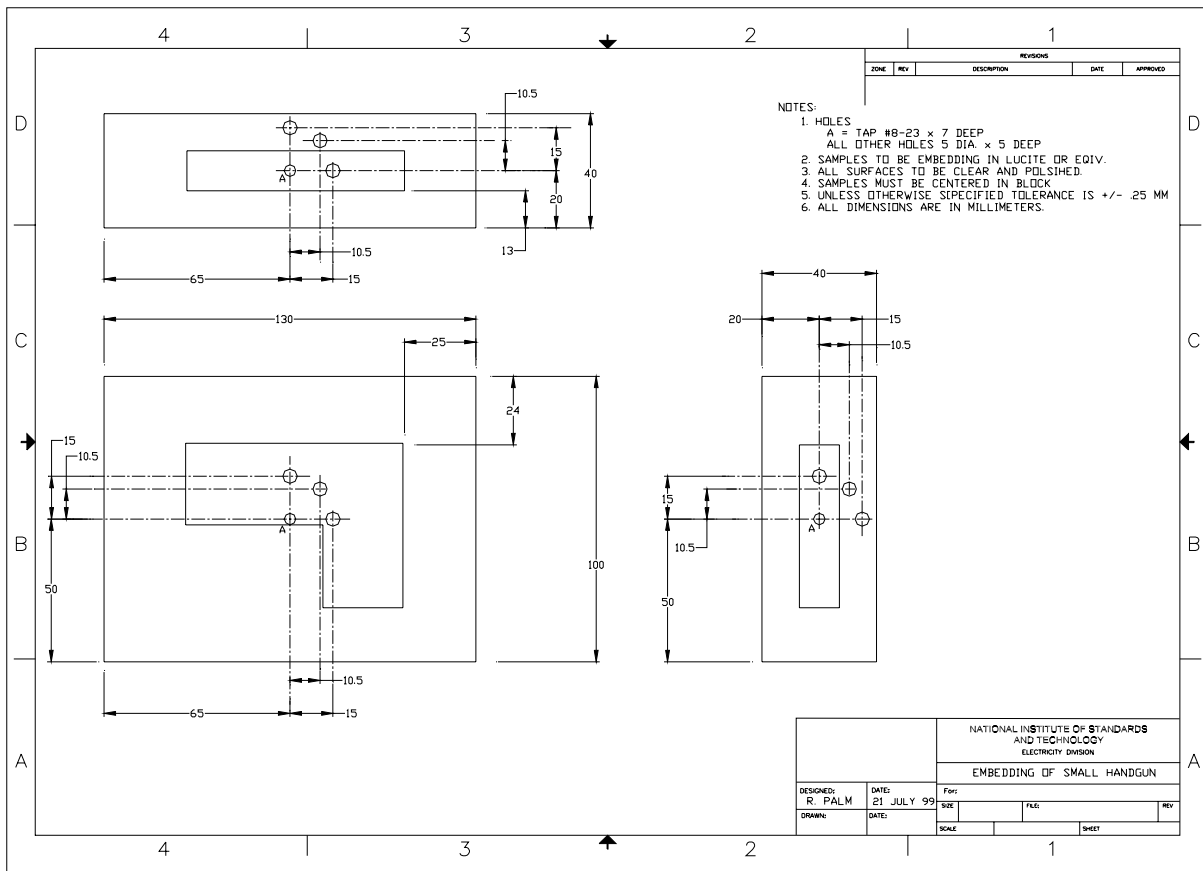
11



### 5.1.2 Handgun

This section contains the following mechanical drawings: the replica of a handgun, a *large object size test object*; and the location of the *test object* within the encasement.





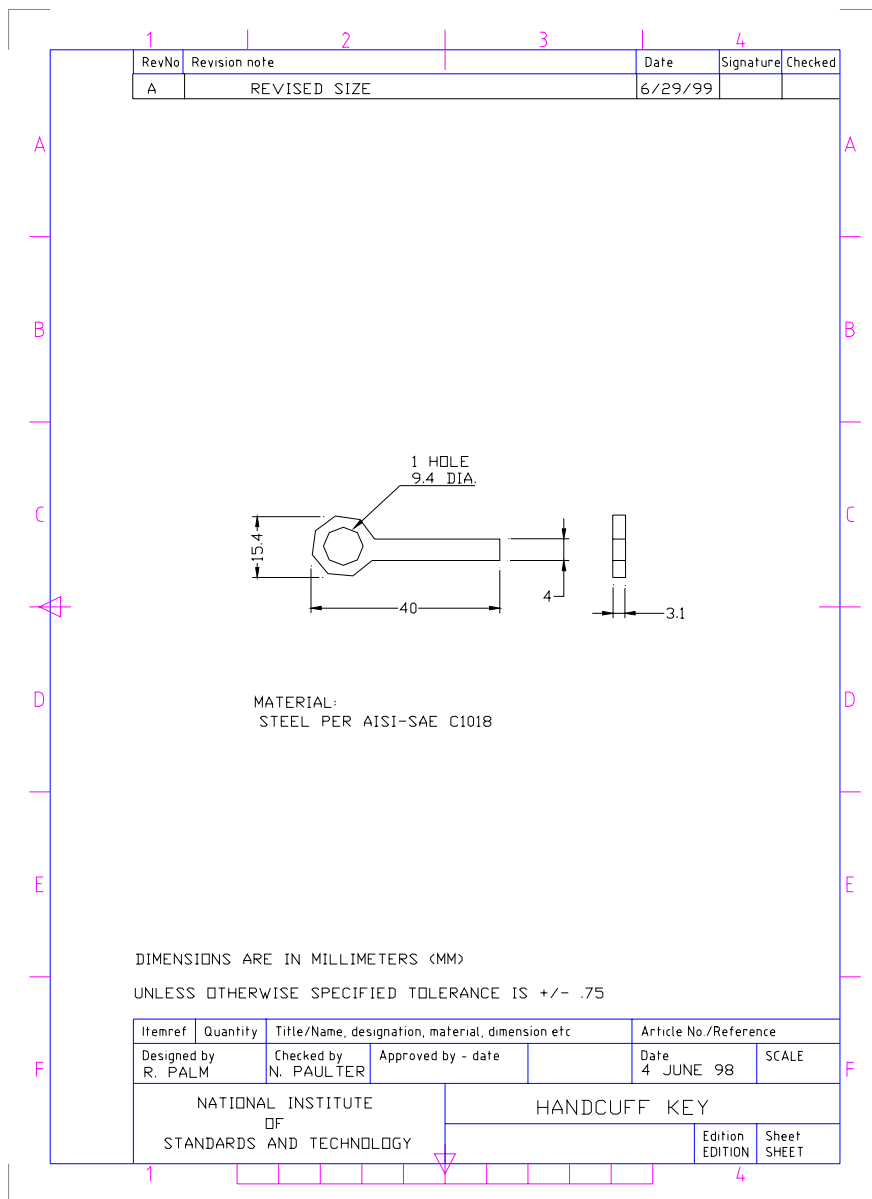


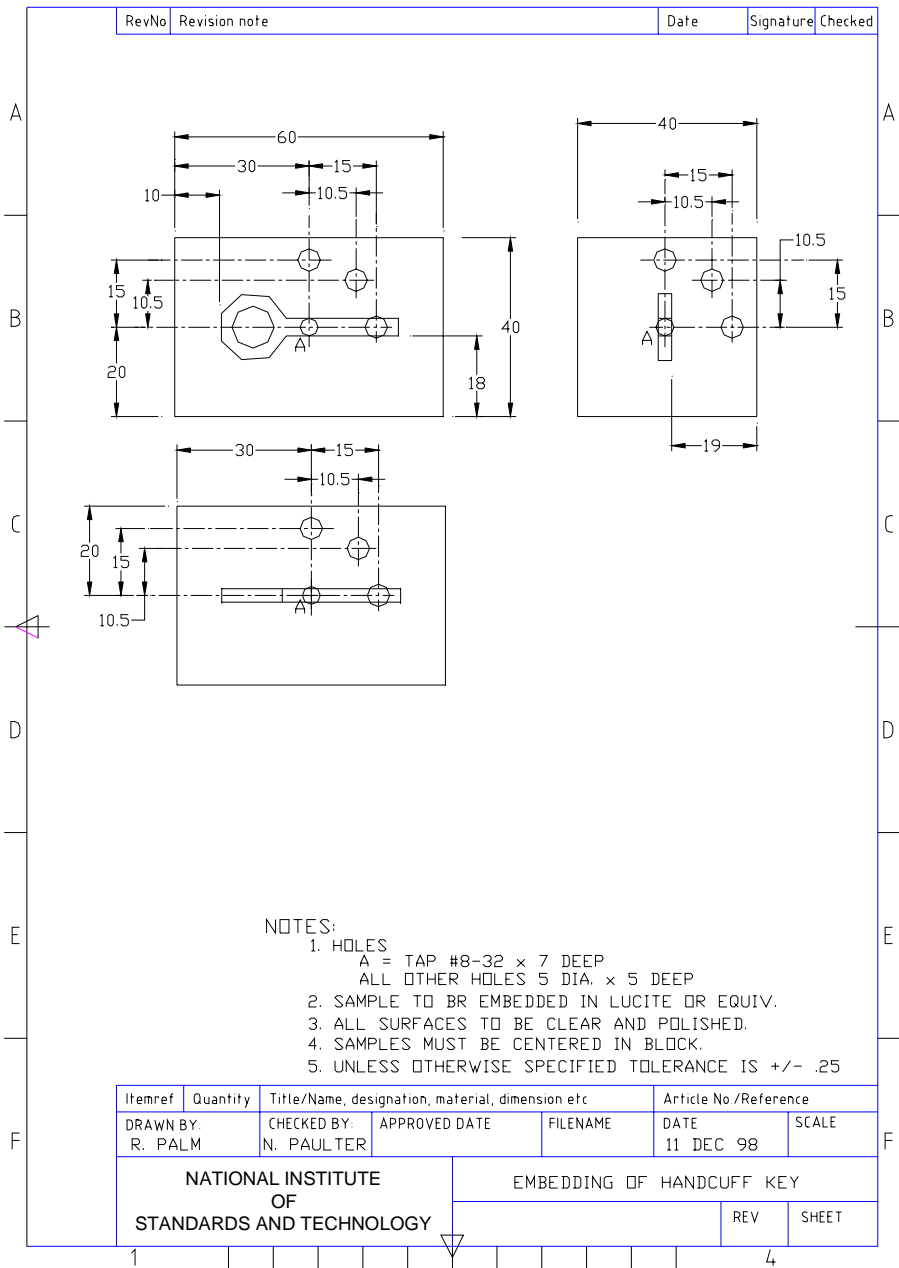
## 5.2 Medium Object Size Test Objects

The following mechanical drawings are replicas of the small hard-to-find items considered a threat to officer and prisoner safety and that can be used to defeat security measures. These items are replicas of: a handcuff key and a #2 Phillips screwdriver.

### 5.2.1 Handcuff Key

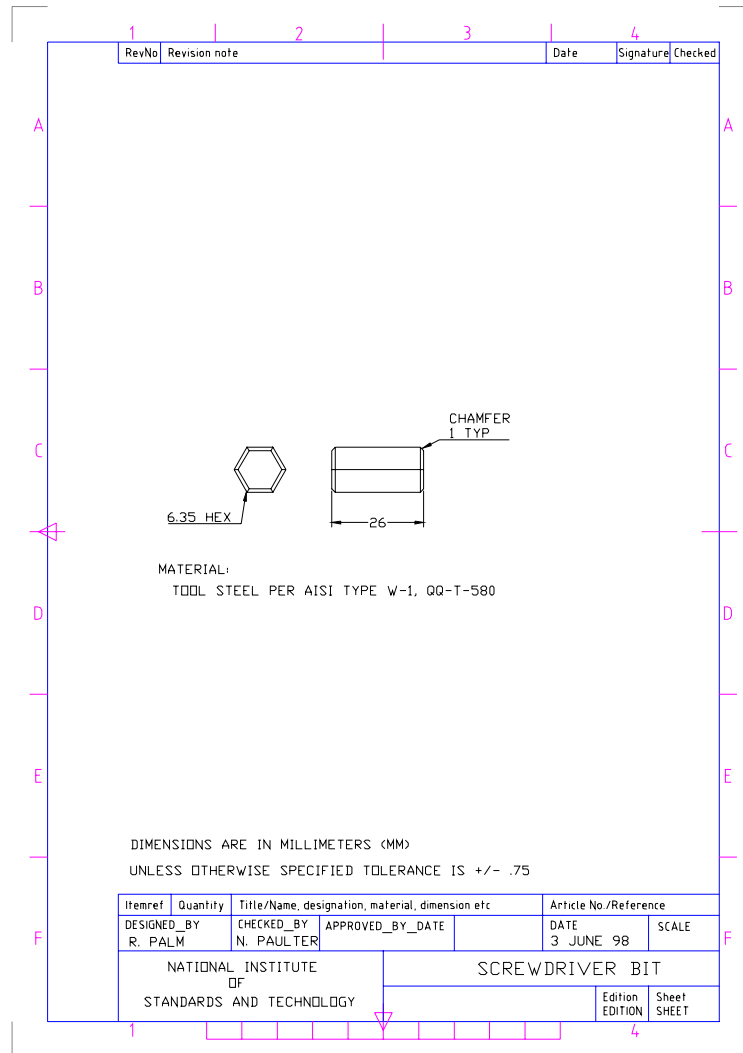
This section contains the following mechanical drawings: a replica of a handcuff key, a *medium object size test object*; and the location of the *test object* within the encasement.

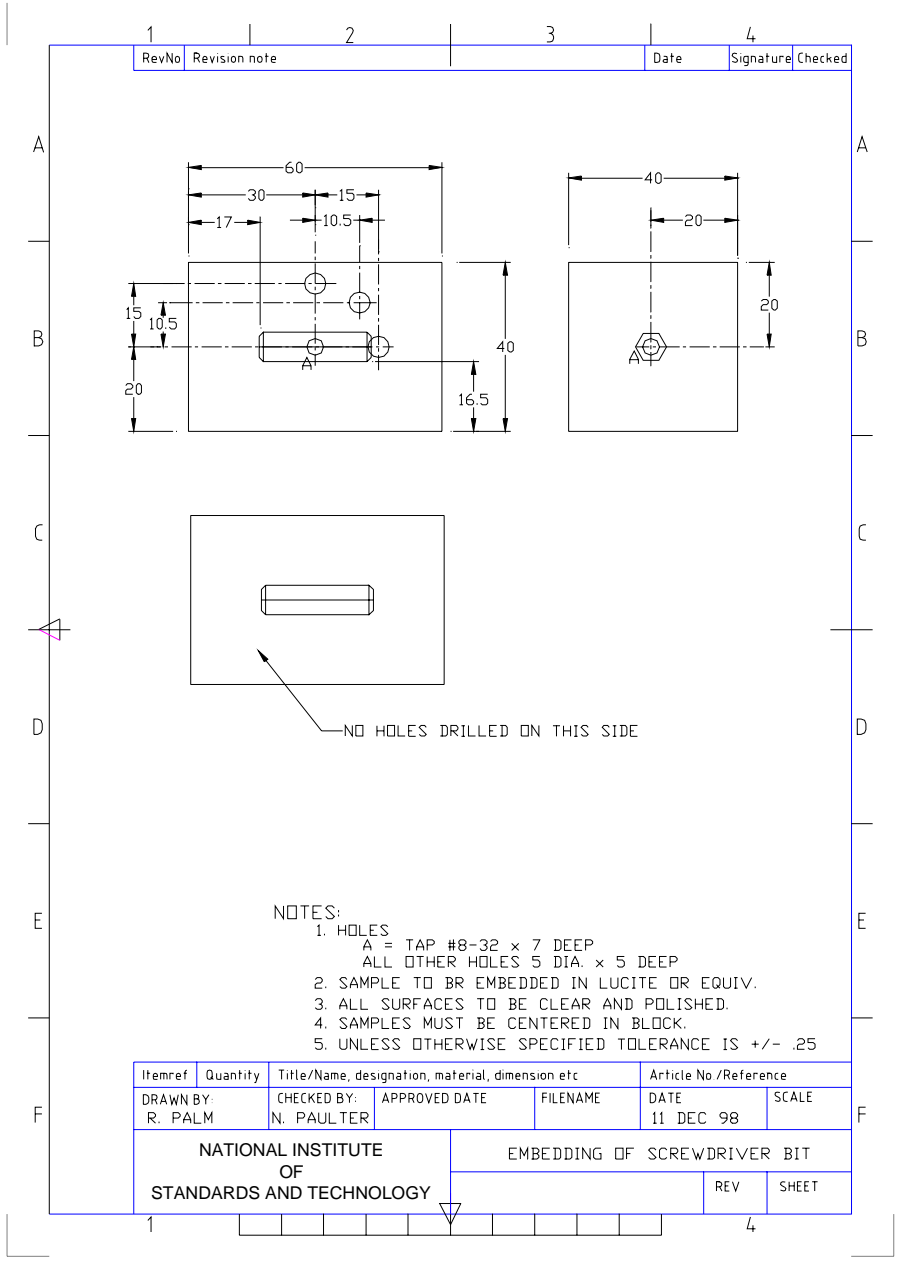




## 5.2.2 Screwdriver Bit, Phillips, #2

This section contains the following mechanical drawings: a replica of a #2 Phillips screwdriver bit, a *medium object size test object*; and the location of the *test object* within the encasement.





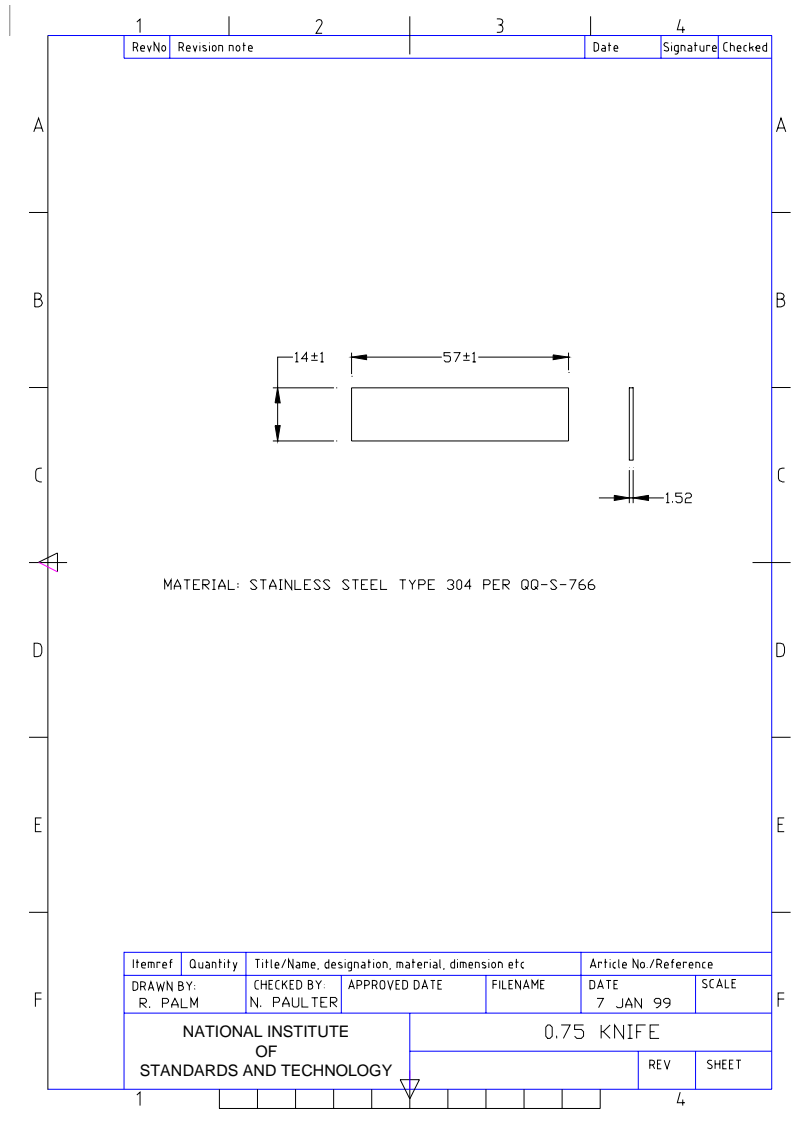
### 5.3 Innocuous Item Test Objects

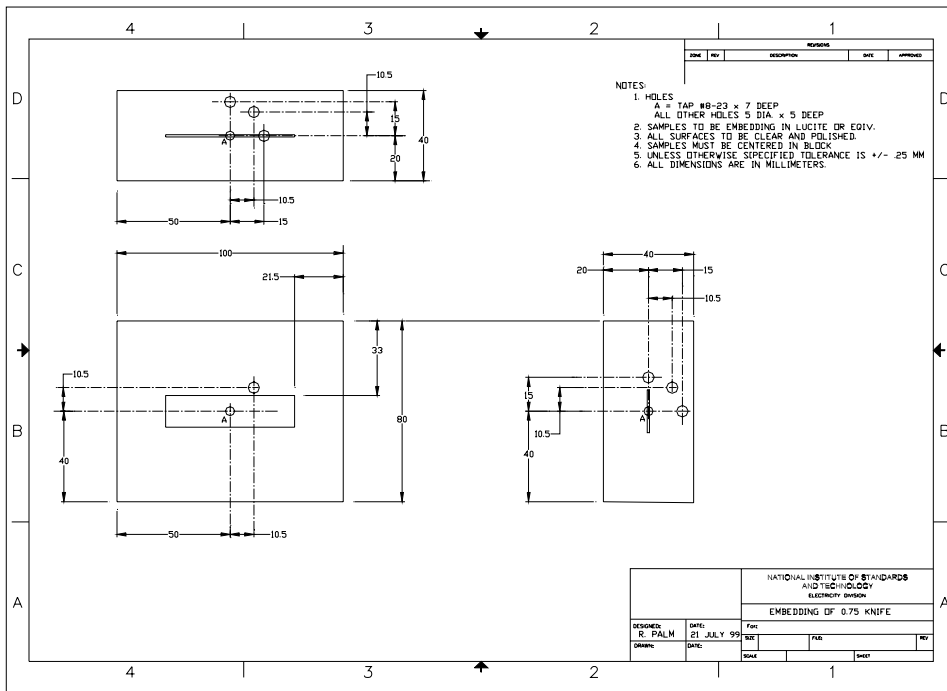
#### 5.3.1 Large Object Size

The *innocuous item test object* is a scaled replica of the knife, a *large object size test object*. All dimensions of the *innocuous item test object* shall be 0.75 % of the dimensions of the *large object size test object*.

##### 5.3.1.1 Reduced Scale Knife

This section contains mechanical drawings of the 0.75 % scaled replica of the knife (see sec. 5.1), an *innocuous item test object*, that are arranged in the following order: the mechanical drawing of the replica of the 0.75 % scaled replica of the knife and the location of the scaled replica within the encasement.



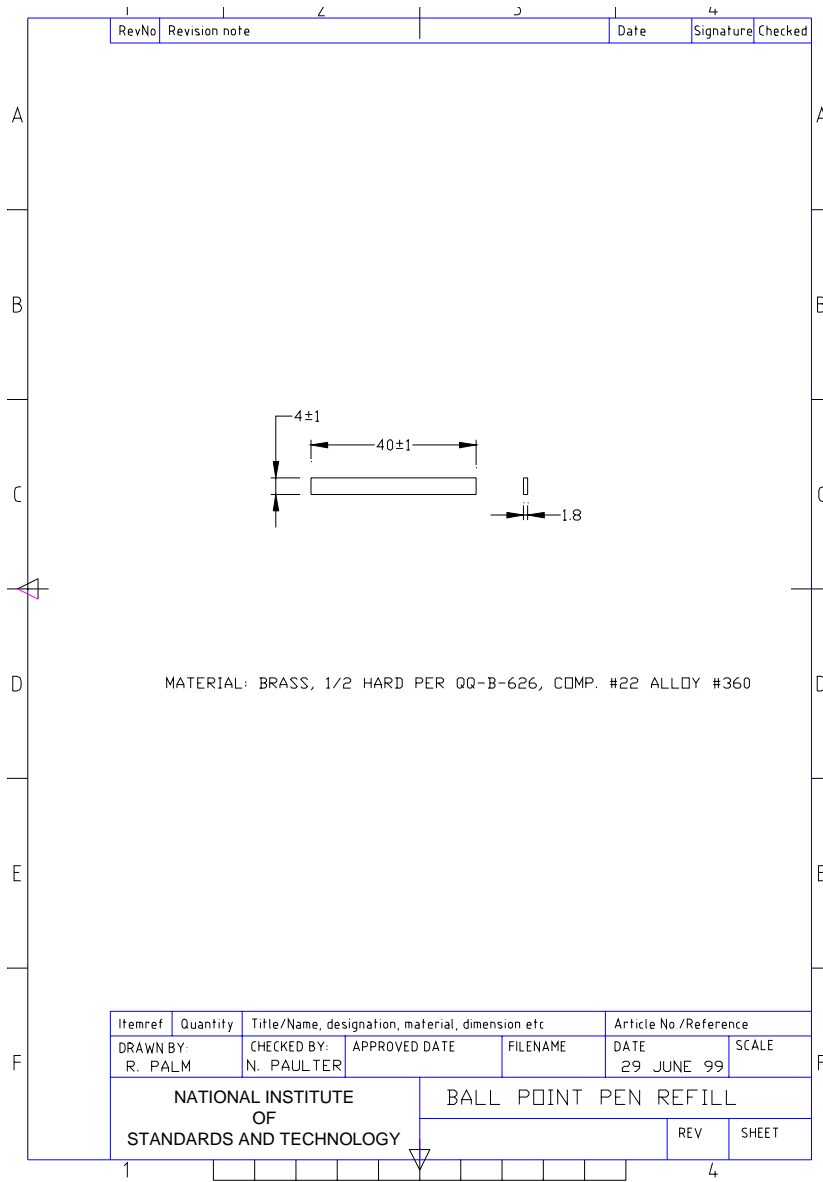


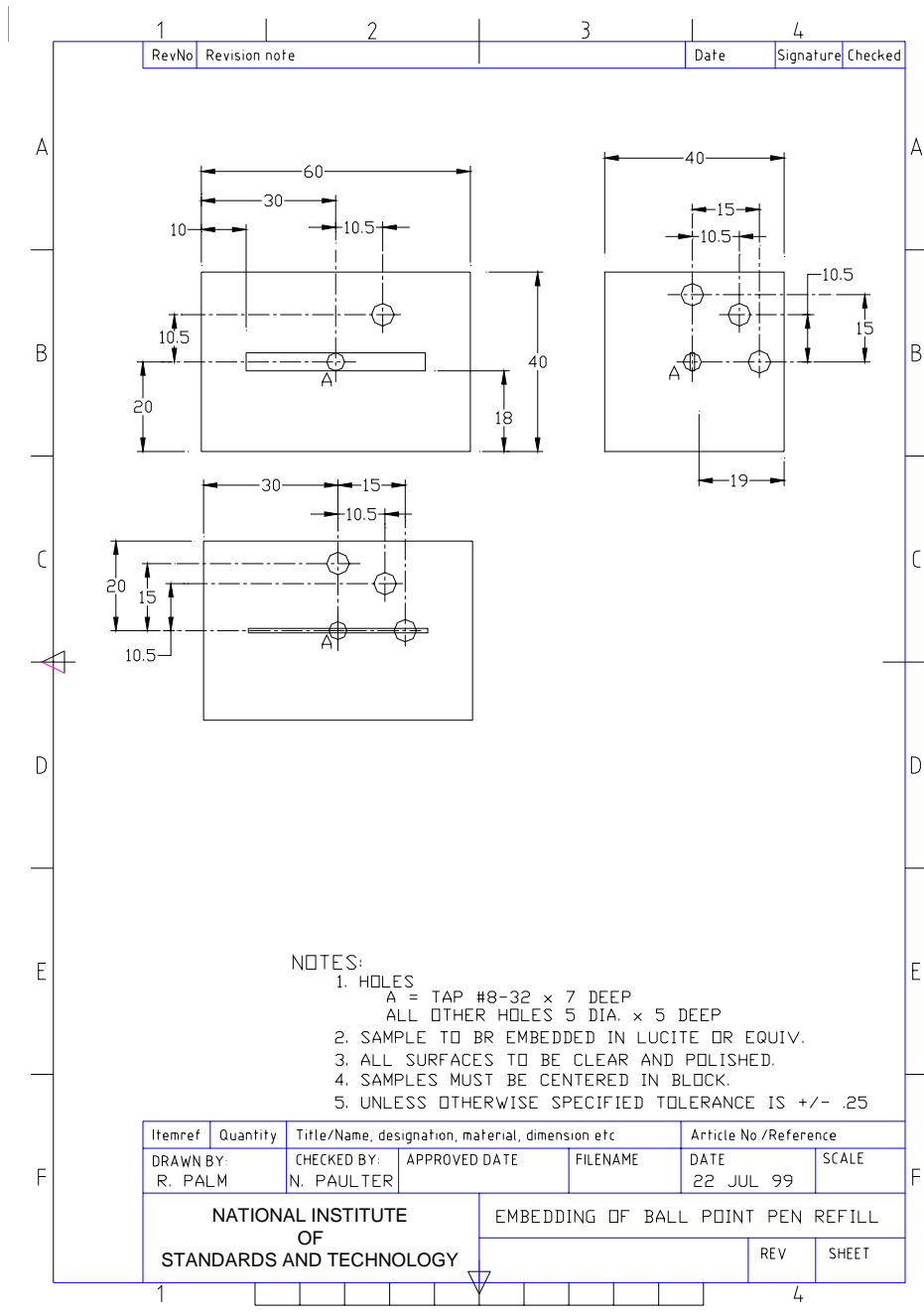
### 5.3.2 Medium Object Size

The *innocuous item test object* is the following object.

#### 5.3.2.1 Pen Refill

This section contains mechanical drawings of the replica of a pen refill arranged in the following order: the mechanical drawing of the pen refill and the location of the replica within the encasement.







## **6. REPORT SHEETS**

Report sheets are provided on the following pages, including instructions for reporting any data electronically.

## 6.1 Requirements for Acceptance Report Sheet

	Pass/Fail	Yes/No	Explanation for failure or lack of compliance
<b>2.1 Safety Specifications and Requirements</b>			
2.1.1 Electrical			
2.1.2 Mechanical			
2.1.3 Exposure			
2.1.4 Warning Labels			
<b>2.2 Electrical Requirements</b>			
2.2.1 Power			
2.2.1.1 AC Connector			
2.2.1.2 Surge Protection			
2.2.2 EEPROM Program Storage			
2.2.3 Burn-In			
<b>2.3 Detection Performance Specifications</b>			
2.3.1 Detection Sensitivity <sup>1</sup>			
2.3.2 Speed <sup>1</sup>			
2.3.3 Throughput <sup>1</sup>			
2.3.4 Repeatability <sup>1</sup>			
2.3.5 Discrimination			
2.3.5.1 Low Security <sup>1</sup>			
2.3.5.2 High Security <sup>1</sup>			
2.3.6 Body Concealment			
2.3.7 Multiple Metal Objects			
<b>2.4 Operating Requirements</b>			
2.4.1 Operator Controls			
2.4.1.1 Power On/Off Switch			
2.4.1.2 Audio Alarm On/Off Switch			

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<sup>1</sup>Additional Report Sheets required.

	Pass/Fail	Yes/No	Explanation for failure or lack of compliance
2.4.1.3 Detector Reset Button			
2.4.1.4 Detector Sensitivity Programming (Optional)			
2.4.2 Control Panel Error Codes			
2.4.3 Interference			
2.4.3.1 Electromagnetic			
2.4.3.1.1.1 Conducted Emission			
2.4.3.1.1.2 Conducted Susceptibility			
2.4.3.1.2.1 Radiated Emission			
2.4.3.1.2.2 Radiated Susceptibility			
2.4.3.2 Metallic			
2.4.3.2.1 Metal Wall			
2.4.3.2.2 Steel Reinforced Floor			
2.4.3.2.3 Moving Metal Door			
2.4.4 Environmental Ranges and Conditions			
2.4.4.1 Temperature Stability and Range			
2.4.4.2 Relative Humidity Stability and Range			
2.4.4.3 Salt Fog			
2.4.4.4 Fungus			
2.4.4.5 Rain			
2.4.4.6 Sand/Dust			
2.4.4.7 Environmental Corrosion			
2.4.4.8 Solar Radiation (Sunshine)			
<b>2.5 Mechanical Specifications and Requirements</b>			
2.5.1 Dimensions and Weight			
2.5.2 Durability/Ruggedness			
2.5.2.1 Impact Resistance			
2.5.2.1.1 Shock			

	Pass/Fail	Yes/No	Explanation for failure or lack of compliance
2.5.2.1.2 Bump			
2.5.2.1.3 Drop and Topple			
2.5.2.1.4 Free Fall			
2.5.2.1.5 Bounce			
2.5.2.2 Pressure Resistance			
2.5.2.2.1 Slide			
2.5.2.2.2 Tip-Over			
<b>2.6 Functional Requirements</b>			
2.6.1 Audible Alarms			
2.6.1.1 Earphone Jack (Optional)			
2.6.1.2 Metal Object Detection			
2.6.1.3 AC Low Power Condition			
2.6.1.4 System Status			
2.6.1.5 Pass-Through Speed Range Violation			
2.6.1.6 Detection Ready State Violation			
2.6.2 Visual Indicators			
2.6.2.1 Metal Object Detection			
2.6.2.2 AC Power Condition			
2.6.2.3 System Status			
2.6.2.4 Pass-Through Speed Range Violation			
2.6.2.5 Detection Ready State Violation			
2.6.2.6 Detection Ready State (Stop/Go)			
2.6.3 Detection Signal Output Connector			
2.6.4 Interchangeability			
2.6.5 Field Servicing			
<b>2.7 Detector Mount</b>			
<b>2.8 Quality Control and Assurance</b>			
<b>2.9 Documentation</b>			

	Pass/Fail	Yes/No	Explanation for failure or lack of compliance
2.9.1 Operating Instructions			
2.9.1.1 Discussion of Operation			
2.9.1.2 Block Diagram of Major Internal Components			
2.9.2 Operator Training Instructions and Videotape or CD-ROM			
2.9.3 Technical Manual			
2.9.4 Technical Training Manual and Videotape or CD-ROM			
2.9.5 Technical Specifications			
2.9.6 Certification of Inspection and Conformance			
2.9.7 Certification of Test Procedures			
2.9.8 Suggested Maintenance Schedule			
2.9.9 Installation Instructions			
2.9.10 Report Sheets			

## 6.2 Detection Sensitivity Test Report Sheet

The format of the test data is described below. All length/displacement units shall be in centimeters and all sensitivity values in either amperes for an output signal current or volts for an output signal voltage. There shall be a unique record for each test object for each of its possible nine orientations. The character string shown within quotations below shall be included in the record.

Line 1: Model name and number:

Line 2: Test object:

Line 3: Test object orientation:

Line 4: Date of measurement:

The measurement data shall follow these lines and shall appear as four columns, each entry followed by a comma except for the last row entry:

x, z, peak signal amplitude, average signal amplitude

where x is the x-axis position where the detection signal was taken, y is the y-axis position where the detection signal was taken, and signal amplitude is the amplitude of the detection signal.

The measurement data shall also be presented graphically. The data shall be presented with the x-axis range equal to 5 cm less than the portal width and the z-axis range equal to 5 cm less than the portal height, with 10 levels of grey on a logarithmic scale with the lowest value equal to 0.1 % of the maximum value. The axes and key shall be provided and labeled.

### 6.3 Speed Test Report Sheet

The test data shall be reported in a table as shown below.

Detector model name and number:

Test object:

Test object orientation:

Date of measurement:

SPEED (m/s)	ALARM INDICATION	
	YES	NO
0.20		
0.50		
1.00		
1.50		
2.00		

## 6.4 Repeatability Test Report Sheet

Detector model name and number:

Test object:

Test object orientation:

Date of measurement:

TRIAL	ALARM INDICATION		TRIAL	ALARM INDICATION	
	YES	NO		YES	NO
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33		
9			34		
10			35		
11			36		
12			37		
13			38		
14			39		
15			40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		



## 6.5 Discrimination Test Report Sheet

Detector model name and number:

Test object:

Test object orientation:

Date of measurement:

TRIAL	ALARM INDICATION		TRIAL	ALARM INDICATION	
	YES	NO		YES	NO
1			26		
2			27		
3			28		
4			29		
5			30		
6			31		
7			32		
8			33		
9			34		
10			35		
11			36		
12			37		
13			38		
14			39		
15			40		
16			41		
17			42		
18			43		
19			44		
20			45		
21			46		
22			47		
23			48		
24			49		
25			50		

## 7. REFERENCES

The following normative documents contain provisions, which through reference in this text, constitute provisions of this Standards Publication. By reference herein these publications are adopted, in whole or in part, as indicated.

ACGIH-0302 (1996), American Conference of Governmental Industrial Hygienists, *Documentation of the Threshold Limit Values, Sub-Radio Frequency (30 kHz and below) Magnetic Fields*.

ANSI S1.4, 1971, American National Standards Institute, *Specifications for General Purpose Sound Level Meters*.

ASTM Designation F 1468-95, Section 13, American Society for Testing and Materials, *Standard Practice for Evaluation of Metallic Weapons Detectors for Controlled Access Search and Screening, Section 13, Procedure for Testing for Outside Influences: Electrical*.

ASTM Designation F 1532-94, American Society for Testing and Materials, *Standard Guide for Qualification, Selection, Training, Utilization, and Supervision of Security Screening Personnel*.

IEC 68-2-27 1987, International Electrotechnical Commission, *Basic Environmental Testing Procedures, Part 2: Tests - Test Ea and Guidance: Shock*.

IEC 68-2-29 1987, International Electrotechnical Commission, *Basic Environmental Testing Procedures, Part 2: Tests - Test Eb and Guidance: Bump*.

IEC 68-2-31 1982, International Electrotechnical Commission, *Basic Environmental Testing Procedures, Part 2: Tests - Test Ec: Drop and Topple, Primarily for Equipment-type Specimens*.

IEC 68-2-32 1975, International Electrotechnical Commission, *Basic Environmental Testing Procedures, Part 2: Tests - Test Ed: Free Fall*.

IEC 68-2-55 1987, International Electrotechnical Commission, *Basic Environmental Testing Procedures, Part 2: Tests - Test Ee and Guidance: Bounce*.

IEEE C62.41-1991, Institute of Electrical and Electronics Engineers, Inc., *IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits*.

IEEE C62.45-1987, Institute of Electrical and Electronics Engineers, Inc., *Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits*.

IEEE C95.1–1991, Institute of Electrical and Electronic Engineers, *Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz*.

ISO 9001:1994(E), International Organization for Standardization 9001, *Quality systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing*.

FCC 47 CFR Part 15 (1996), Federal Communications Commission, *Code of Federal Regulations; Title 47–Telecommunications; Part 15, Radio Frequency Devices*.

MIL–STD–810E Method 505.3, Military Standard, *Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, Method 505.3, Solar Radiation (Sunshine)*.

MIL–STD–810E Method 506.3, Military Standard, *Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, Method 506.3, Rain*.

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