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American National Standard for the Performance of Checkpoint Cabinet X-Ray Imaging Security Systems

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42

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Institute of Electrical and Electronics Engineers, Inc.

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Abstract: This document establishes standards for the technical performance of cabinet x-ray imaging systems used for screening at security checkpoints and other inspection venues.
Keywords: cabinet x-ray, checkpoint, minimum performance

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American National Standard for the Performance of Checkpoint Cabinet X-Ray Imaging Security Systems

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1. Overview

Numerous measures of imaging performance for x-ray screening systems have been defined over the past several years. For example, penetration, spatial resolution, and wire gauge diameter are well-known and frequently used measures for defining an x-ray system's imaging performance. ASTM F792-01[1] establishes nine tests to determine the performance levels of an x-ray system. These tests have been widely accepted by the x-ray screening community, both manufacturers and users, and are adopted in this standard.

This document establishes minimum performance requirements for the nine tests of the ASTM F792-01 test method as applied to checkpoint cabinet x-ray systems. A well-defined test method and a set of minimum acceptable image-quality standards will provide value to both users and manufacturers of these x-ray imaging security systems. Manufacturers will have a better understanding of the needs, wants, and expectations of the user community and a clearer understanding of the minimum set of imaging goals. It is understood that some users will require image-quality standards higher than the minimum performance required in this standard.

Additionally, this standard provides a number of safety requirements, derived from a variety of standards documents and federal regulations, that are essential to the responsible operation of checkpoint cabinet x-ray systems. These include: radiological safety, electrical and mechanical safety, electromagnetic compatibility, and limitation of x-ray exposure to scanned objects (e.g., photographic film).

[1] Information on references can be found in Clause 2.

Sample test reports are given in Annex A (informative). Selected human-factors engineering considerations are included in Annex B (informative).

1.1 Scope

This document establishes standards for the technical performance of cabinet x-ray imaging systems used for screening at security checkpoints and other inspection venues. Included are all x-ray systems designed primarily for the inspection of baggage at airline, railroad, and bus terminals, and in similar facilities. An x-ray tube used within a shielded part of a building, or x-ray equipment that may temporarily or occasionally incorporate portable shielding, is not considered to be a cabinet x-ray system.

Hereinafter, systems covered by the scope of this standard are referred to as the system.

This standard applies to x-ray imaging equipment with all of the following characteristics:

- Meet the definition of cabinet x-ray systems as given in 21 CFR 1020.40
- Operate at or above 120 kV
- Have tunnel nominal dimensions of up to 1.1 m × 1.1 m
- Provide a single-view direct-projection image as the primary image
- Are used to examine items to detect prohibited and illicit materials at security-checkpoint locations (e.g., airports, seaports, land border crossings, office buildings, court houses, correctional institutions, nuclear power facilities, military facilities, commercial shipping and receiving stations, stations used for manifest verification)

For further clarification, systems included in this standard can be those with or without organic/inorganic differentiation, with or without active or passive threat alerts, and those incorporating multi-view and computed-tomography (CT) imaging (if the primary image presented is a single-view projection image), if they have all of the characteristics found in the list above.

This standard therefore is not intended for x-ray imaging systems with any of the following characteristics:

- Operate at potentials that are less than 120 kV
- Are not cabinet systems (e.g., open bomb-squad systems)
- Do not present a direct-projection image
- Can provide a projection image only through image reconstruction from multiple views
- Are based primarily on the use of CT
- Are used for medical diagnostic imaging
- Are used for non-destructive evaluation (NDE) or non-destructive testing (NDT), industrial quality control (e.g., food inspection), industrial sortation of recyclables or natural resource extraction, systems used for scientific research purposes
- Are based only on backscattered or coherently scattered x-rays

This standard specifies minimum requirements and test procedures for x-ray imaging performance, radiation-limitation requirements, and electrical, mechanical, and environmental requirements. This standard addresses technical image-quality performance, not threat-detection performance.

1.2 Purpose

Screeners frequently use the images provided by checkpoint x-ray systems to detect weapons and contraband materials, as well as to verify manifests (to determine that the contents of a package are what they are purported to be). For these applications, this standard is intended to provide procurers and/or prospective users of checkpoint x-ray systems with: test methods that facilitate performance comparisons among systems, and the minimum acceptable imaging-performance requirements. These values are achievable in the current state of the art of production checkpoint x-ray systems. Additionally, a variety of factors essential for the safe operation of checkpoint x-ray systems are assembled and standardized in this document.

While it appears logical that better imaging performance will result in better screening performance, the user is cautioned that the correlation between specific imaging-performance metrics and detection performance has not been established on a strict scientific basis. In addition, there may be trade-offs among imaging-performance parameters. For example, higher penetration may result in decreased contrast sensitivity. Consequently, users are encouraged to evaluate candidate checkpoint x-ray systems against their specific requirements whenever possible, and especially in cases in which the application is atypical.

The tests specified in this standard may be used for type testing. Type tests are intended to demonstrate that production systems made according to a specific design meet defined performance criteria.

2. Normative references

The following normative documents contain provisions which, through reference in the text of this standard, also constitute provisions of ANSI N42.44. For dated references or those with specified editions, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies. Users of this standard should note that alternative referenced standards specified in this standard may not fulfill the legal requirements and practices in all countries. Care should be taken to ensure regulatory compliance.

ASME B20.1, Safety Standard for Conveyors and Related Equipment.[2]

ASTM F792-01e2, Standard Practice for Evaluating the Imaging Performance of Security X-Ray Systems.[3]

ASTM F1039, Standard Test Method for Measurement of Low Level X-Radiation Used in X-Ray Security Screening Systems.

CISPR 11, Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment—Electromagnetic Disturbance Characteristics—Limits and Methods of Measurement.[4]

FDA Rules, Code of Federal Regulations, Title 21, Part 1020, Performance Standards for Ionizing Radiation Emitting Products, Section 1020.40—Cabinet x-ray systems (hereinafter referred to as 21 CFR 1020.40).[5]

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[2] ASME publications are available from the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990, USA (http://www.asme.org/).

[3] ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).

[4] CISPR documents are available from the International Electrotechnical Commission, 3, rue de Varembé, Case Postale 131, CH 1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). They are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[5] Title 21 of the CFR is reserved for rules of the US Food and Drug Administration. Title 21 publications are available from the US Food and Drug Administration online at http://www.fda.gov.

FCC Rules, Code of Federal Regulations, Title 47—Telecommunications, Part 15—Radio Frequency Devices (hereinafter referred to as 47 CFR 15).[6]

FCC Rules, Code of Federal Regulations, Title 47—Telecommunications, Part 18—Industrial, Scientific, and Medical Equipment (hereinafter referred to as 47 CFR 18).

IEC 60204-1, Safety of machinery—Electrical equipment of machines—Part 1: General requirements.[7]

IEC 60601-2-28 (1993), Medical electrical equipment—Part 2: Particular requirements for the safety of X-ray source assemblies and X-ray tube assemblies for medical diagnosis.

IEC 61000-4-2, Electromagnetic Compatibility (EMC)—Part 4-2: Testing and measurement techniques—Electrostatic discharge immunity test.

IEC 61000-4-3, Electromagnetic Compatibility (EMC)—Part 4-3: Testing and measurement techniques—Radiated, radio-frequency, electromagnetic field immunity test.

IEC 61000-4-4, Electromagnetic Compatibility (EMC)—Part 4-4: Testing and measurement techniques—Electrical fast transient/burst immunity test.

IEC 61000-4-5, Electromagnetic Compatibility (EMC)—Part 4-5: Testing and measurement techniques—Surge immunity test.

IEC 61000-4-6, Electromagnetic Compatibility (EMC)—Part 4-6: Testing and measurement techniques—Immunity to conducted disturbances, induced by radio-frequency fields.

IEC 61000-4-11, Electromagnetic Compatibility (EMC)—Part 4-11: Testing and measurement techniques—Voltage dips, short interruptions and voltage variations immunity tests.

IEC 61010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use—Part 1: General requirements. [8]

3. Definitions

The following definitions apply to ANSI/IEEE standards that have been developed at the request of the Department of Homeland Security (DHS) for instruments to be used by DHS and emergency responders.

3.1 air kerma: The sum of the initial kinetic energies of all the charged particles liberated by uncharged particles (e.g., photons) in a mass of air, divided by that mass, in the limit as the mass goes to zero. The special name for the unit of kerma is gray (Gy), with 1 Gy = 1 joule per kilogram.

3.2 backscattered x-rays: X-rays that are scattered at backward angles, roughly toward the x-ray source.

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[6] CFR publications are available from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, USA.

[7] IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[8] This standard is also known as UL 61010-1, Standard for Safety Electrical Equipment for Measurement, Control, and Laboratory Use; Part 1: General Requirements and is available from Underwriters Laboratories via COMM 2000 at http://www.comm-2000.com/default.aspx.

3.3 cabinet x-ray system: An x-ray system with the x-ray tube installed in an enclosure that, independent of existing architectural structures except the floor on which it may be placed, is intended to contain at least that portion of a material being irradiated, provide radiation attenuation, and exclude personnel from its interior during generation of x radiation.

3.4 checkpoint: For the purposes of this standard, an area where x-ray equipment is used to examine items to identify security threat material or other illicit or prohibited materials, which may be placed in baggage or parcels and/or is concealed within an item.

3.5 coherently scattered x-rays: X-rays that are elastically scattered with no loss in energy.

3.6 degradation (of performance): An undesired departure in the operational performance of the system from its intended performance.

3.7 exposure: The absolute value of the total charge of the ions of one sign produced in a mass of (dry) air when all the electrons and positrons liberated or created by photons in the air are completely stopped in air, divided by that mass of air, in the limit as the mass goes to zero. The special name for the unit of exposure was roentgen (R), with $1\ \text{R} = 2.58 \times 10^{-4}\ \text{C kg}^{-1}$ (exactly). Note that the roentgen is no longer recognized in the International System of Units (SI) and exposure has been largely replaced by air kerma. At the x-ray energies of interest here, the relation between air kerma (K_{air}) and exposure (X) is $K_{\text{air}} = 0.00876\ \text{Gy R}^{-1}\ X$.

3.8 projection (or transmission) image: Pertains to conventional x-ray technology in which x-rays pass through an object and create a shadowgram, which is the result of the differential attenuation due to variations of composition, density and thickness of every portion of the object in the path of the x-ray beam.

3.9 type test: For the purpose of this standard, a test that can be performed by manufacturers or other parties on one or more samples of the system, representative of production systems, with the objective of determining if the system, as designed and manufactured, meets the requirements of this standard.

4. General considerations

All tests in this standard may be considered as type tests.

4.1 Special word usage

The following word usage applies:

- The word “shall” signifies a mandatory requirement (except where an appropriate qualifying statement is included to indicate that there may be an allowable exception).
- The word “should” signifies a recommended specification or method.
- The word “may” signifies an acceptable method or an example of good practice.

4.2 Environmental factors

It is recognized that checkpoint x-ray systems are used predominantly in controlled environments. To insure uniformity of test results, all tests in this standard shall be performed under standard environmental test conditions. The ranges of acceptable test conditions are shown in Table 1 under “Standard test conditions.”

If the system is intended for operation in environmental conditions significantly outside the ranges specified in Table 1, additional testing should be done to demonstrate that the imaging performance reported for standard test conditions remains unchanged at the low-temperature/low-humidity limit and at the high-temperature/high-humidity limit of the intended range.

Table 1—Standard test environmental conditions

Influence quantity (ambient)	Standard test conditions
Air temperature	22 ºC ± 5 ºC (71.6 ºF ± 9.0 ºF)
Relative humidity	30% to 75%, non-condensing
Atmospheric pressure	86 kPa to 106 kPa (645 mm Hg to 795 mm Hg)

The value of ambient air temperature, relative humidity, and atmospheric pressure at the time of the test shall be recorded (see, e.g., Annex A). The environmental conditions stated in this standard take priority over other environmental conditions stated in the referenced standards.

4.3 Radiological safety

Checkpoint x-ray systems shall comply with the requirements of 21 CFR 1020.40.

4.4 Fire, electrical, and mechanical safety

Checkpoint x-ray systems shall meet the existing fire, electrical, and mechanical safety requirements of the following indicated standards:

a) IEC 61010-1 and/or UL 61010-1

b) IEC 60601-2-28:1993 for:

   1) Products having a high-voltage cable external to the high-voltage assembly. These products shall comply with Clause 16 of IEC 60601-2-28:1993.

   2) Products having field-replaceable x-ray tubes. These products shall comply with subclauses 45.2 and 45.7 of IEC 60601-2-28:1993.

c) ASME B20.1 and/or IEC 60204-1 for requirements for safety of machinery

4.5 Electromagnetic compatibility

Checkpoint x-ray systems shall meet the electromagnetic-compatibility requirements of the indicated regulations or standards. Subclauses 4.5.3 to 4.5.8 specify testing parameters to be used in conjunction with the indicated IEC 61000 testing standards. Performance criteria (classifications) pertaining to the requirements listed in 4.5.3 to 4.5.8 are detailed in Table 2.

Table 2—Performance criteria for electromagnetic-compatibility requirements

Performance criteria	Description
A	The apparatus shall continue to operate as intended during and after the disturbance. No degradation of imaging performance (see Clause 5) or loss of function is allowed.
B	Temporary loss of function or degradation of performance that ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention. No change of actual operating state or stored data is allowed. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended.
C	Temporary loss of function or degradation of performance, the correction of which requires operator intervention. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended.

4.5.1 Conducted emissions

47 CFR 15, 47 CFR 18, and/or IEC CISPR 11 (Class A)

4.5.2 Radiated emissions

47 CFR 15, 47 CFR 18, and/or IEC CISPR 11 (Class A)

4.5.3 Electrostatic discharge

IEC 61000-4-2, with the following settings and conditions:

a) Contact discharge mode at 2 kV, 4 kV, and 6 kV
b) Air discharge mode at 2 kV, 4 kV, 8 kV, and 15 kV
c) Ten equipment discharge test points plus both vertical and horizontal coupling planes, positive and negative discharge waveform polarities
d) Performance criterion, Class B

4.5.4 Radiated RF immunity

IEC 61000-4-3, with the following settings and conditions:

a) 80 MHz to 1.0 GHz, 10 V/m
b) 1.4 GHz to 2.0 GHz, 3 V/m
c) 2.0 GHz to 4.0 Ghz, 1 V/m
d) Four sides of EUT, 1% steps, 2.8 s dwell, AM, 80%, 1 kHz sine wave
e) Class A

4.5.5 Electrical fast transient/burst immunity test

IEC 61000-4-4, with the following settings and conditions:

a) AC and DC power ports at 0.5 kV, 1 kV, and 2 kV
b) Signal lines over 3 m at 0.25 kV, 0.5 kV, and 1 kV
c) Class B

4.5.6 Surge immunity test

IEC 61000-4-5, with the following settings and conditions:

a) AC power port at 2 kV line-to-earth, 1 kV line-to-line at 0°, 90°, 180°, and 270°
b) DC power ports at 0.5 kV line-to-earth, 0.5 kV line-to-line
c) Signal lines over 5 m at 1 kV line-to-earth
d) Positive and negative polarity, 5 surges per mode of appearance
e) For non-linear devices contained in the circuitry, lower voltage levels up to the limit are also to be tested
f) Class B

4.5.7 Immunity to conducted disturbances, induced by radio-frequency fields

IEC 61000-4-6, with the following settings and conditions:

a) 10 V rms, 150 kHz to 80 MHz
b) Power ports and signal lines over 3 m, 1% steps, 2.8 s dwell
c) Class B

4.5.8 Voltage dips, short interruptions, and voltage variations immunity tests

IEC 61000-4-11, with the following settings and conditions:

a) 30% reduction for 0.5 periods (10 ms), performance criterion, Class B
b) 60% for 5 periods (100 ms), performance criterion, Class C
c) 60% for 50 periods (1 s), performance criterion, Class C
d) 95% for 250 periods (5 s), performance criterion, Class C

4.6 Limitation of x-ray exposure to photographic film

In order to limit the effects of x-ray exposure on photographic film, the radiation exposure in a single screening, as measured using ASTM Test Method F1039, shall be less than 2.58×10^{-7} C/kg (i.e., an air kerma of less than 8.76 μGy or, equivalently, an exposure of less than 1 mR). Compliance with this limit assures what is generally regarded as film-safe inspection, at least for most unprocessed consumer films (i.e., speeds below ISO 800) undergoing a limited number of screenings. However, it is acknowledged that newer technologies, such as multi-view and CT checkpoint systems, might offer improved security performance but with increased exposure.

The radiation exposure in a single screening shall be reported for the technique (i.e., x-ray tube voltage and current, and conveyor belt speed) that produces the maximum exposure to scanned objects, and the technique parameter settings, if known, shall be recorded in test documentation (see, for example, Annex A). It is recommended that exposure be similarly reported for routine screening, and for any special techniques available to the operator.

5. Imaging-performance evaluation procedures

The test procedures in this standard are meant to add specificity to the test procedures of ASTM F792-01e2 for the system. This standard shall be used in conjunction with ASTM F792-01e2. Available ASTM F792-01e2 test objects (see ASTM ADJF0792) have an outer case similar to that of a briefcase. To more realistically simulate routine screening and to simplify and better facilitate reproducibility of image-performance test results, this standard has more restrictive requirements on test-object placement and orientation (see 5.2) than does ASTM F792-01e2. Thus, if the procedures of this standard are more restrictive than those of ASTM F792-01e2, this standard's procedures take precedence.

5.1 Imaging-performance test object

The test object used in this document is that specified in ASTM F792-01e2. It is composed of fixtures for the following nine tests:

Test 1—Wire display

Test 2—Useful penetration

Test 3—Spatial resolution

Test 4—Simple penetration

Test 5—Thin organic imaging

Test 6—Image-quality-indicator (IQI) sensitivity

Test 7—Organic/inorganic differentiation

Test 8—Organic differentiation

Test 9—Useful organic differentiation

Available ASTM F792-01e2 test objects have solid copper wires that are not tinned (see ASTM ADJF0792). The use of non-tinned, solid copper wires is required for Test 1, Test 2, and Test 3 in this standard. Note also that the indicated positions of the plastics in Test 9 of the test object in Figure 1 of ASTM F792-01e2 are reversed from the actual positions in the available test objects (see ASTM ADJF0792), so care should be taken in interpreting and reporting results for that test.

5.2 Imaging-performance test procedure

The test object shall be placed alone and in its case such that one surface of the case is in contact with the x-ray conveyor belt. The surface in contact with the conveyor belt should be chosen such that the test object is more nearly perpendicular to the x-ray beam axis. Thus, if the x-ray beam is primarily directed vertically upward ("up-shooter"), the case should lie flat; if the x-ray beam is primarily directed horizontally ("side-shooter"), the case should be positioned on edge. An exception is permitted for systems in which the x-ray beam is primarily directed vertically downward ("down-shooter"), for which the test object shall be positioned with the bottom surface of the case parallel to the conveyor surface but may be elevated to a height above the conveyor belt of up to one-fourth of the vertical tunnel dimension.

In all cases, the test object (in its case) shall be scanned with its long dimension parallel to the direction of the conveyor motion. The case may be positioned laterally (with respect to the direction of the conveyor motion) for optimal performance in any test.

In all cases, the placement and orientation of the test object shall be reported in the test procedure with the corresponding test results (see, for example, Annex A).

5.3 Imaging-performance evaluation considerations

a) If image-enhancement features are available to the operator in normal use, these may be used to achieve the best possible x-ray image. Examples are zoom, high penetration, edge enhancement, expanded density, black-and-white reverse, and pseudo-color. The use of these features shall be recorded in test documentation (see, for example, Annex A).

b) Any deviation from specified measurement procedures shall be described in test documentation.

6. Minimum acceptable imaging performance

Table 3 shows minimum acceptable performance for each of the imaging tests. Different minimum acceptable performance requirements are given for tunnels for which any dimension, width or height, is either <70 cm or ≥ 70 cm. This reflects the fact that tunnel dimension and the consequent size of bags or parcels being screened can influence imaging performance for certain of the tests. Therefore, a large tunnel system, with greater source-to-object distance, can degrade performance when compared to a smaller tunnel with a smaller source-to-object distance. This phenomenon is reflected in a relaxation of acceptable minimum performance for certain of the tests for the larger tunnel systems.

Note that for systems without organic/inorganic differentiation there is no requirement for meeting the minimum acceptable performance indicated for Test 7, Test 8, and Test 9.

Table 3—Minimum acceptable performance

Test #	Description	Largest tunnel dimension	
		<70 cm	≥70 cm
1	Wire display: Smallest wire noted under 0 mm Al	32 AWG	32 AWG
2	Useful penetration: Smallest wire noted under 9.5 mm Al Smallest wire noted under 15.9 mm Al Smallest wire noted under 22.2 mm Al	30 AWG 30 AWG 30 AWG	30 AWG 24 AWG 24 AWG
3	Vertical wire resolution: Horizontal wire resolution:	1.6 mm 1.6 mm	1.6 mm 1.6 mm
4	Simple penetration (steel):	22 mm	22 mm
5	Thin organic imaging (thicknesses of Delrin®)[a]: Distinguish 1 mm and 3 mm Distinguish 3 mm and 5 mm	Yes Yes	Yes Yes
6	IQI sensitivity (smallest hole discerned): Delrin® (plastic): 4T 2T 1T Steel: 4T 2T 1T	3 (9.6 mm) 4 (6.4 mm) No minimum No minimum No minimum No minimum	4 (12.8 mm) 4 (6.4 mm) No minimum No minimum No minimum No minimum
7[b]	Inorganic/organic differentiation:	Yes	Yes
8[b]	Organic differentiation: Behind 0 mm steel: PVC/XM®[c] XM®/nylon	Yes Yes	Yes Yes
9[b]	Useful organic differentiation: Behind 1.6 mm steel: PVC/XM® XM®/nylon Behind 3.2 mm steel: PVC/XM® XM®/nylon Behind 4.8 mm steel: PVC/XM® XM®/nylon	Yes Not required Not required Not required Not required Not required	Yes Not required Not required Not required Not required Not required

[a] Delrin® is a registered trademark of E.I. Du Pont de Nemours and Company Corporation. This information is given for the convenience of users and does not constitute an endorsement by the IEEE of these products. Equivalent products may be used if they can be shown to lead to similar results.

[b] Not required for systems without organic and inorganic differentiation.

[c] XM is a division of Van Aken International. For purposes of this table, XM represents the TNT stimulant XM-02-X manufactured by the XM Division of Van Aken International, Rancho Cucamomga, CA. This information is given for the convenience of users and does not constitute an endorsement by the IEEE of these products. Equivalent products may be used if they can be shown to lead to similar results.

Annex A

(informative)

Test reports

Sample test reports, covering measurements of imaging performance and of exposure to scanned objects, are given in this annex.

The imaging-performance check form is directly modeled after that used in ASTM F792-01e2, but with guidance on Test 9 to clarify an inconsistency in position of the plastic samples. The check form should greatly simplify the recording of distinguishable features according to ASTM F792-01e2 and facilitate the transfer of the test results to the summary table that follows.

The x-ray exposure test report includes only exposure to the scanned object (see sample report). Conformance with leakage-radiation requirements is covered in the FDA Code of Federal Regulations, Title 21, Part 1020. Most of the x-ray security-screening systems covered here have only one scanning mode, and the parameter settings (x-ray tube kV and mA; belt speed) might not be displayed. In that case, place an appropriate indication, such as “standard/routine,” in the "Parameter settings" column.

ANSI N42.44 Cabinet X-Ray System Test Report

Doc. Ref. #:______________, Page 1 of 4

Tester:	Place:	Date/time:
X-ray system mfr:	Model:	Serial #:
Tunnel height, H (cm):	Tunnel width, W (cm):	Total H+W (cm):
Beam orientation (up-, down-, side-shooter):		Software version:
Monitor manufacturer:	Model:	Serial #:
Ambient temperature:	Relative humidity:	Pressure:

Test-Object Placement

Lateral position on belt (left, middle, right, facing direction of motion):
Orientation (horizontal/flat, vertical/upright):
Height above belt (cm) (for down-shooters only):

ANSI N42.44 Cabinet X-Ray System Test Report

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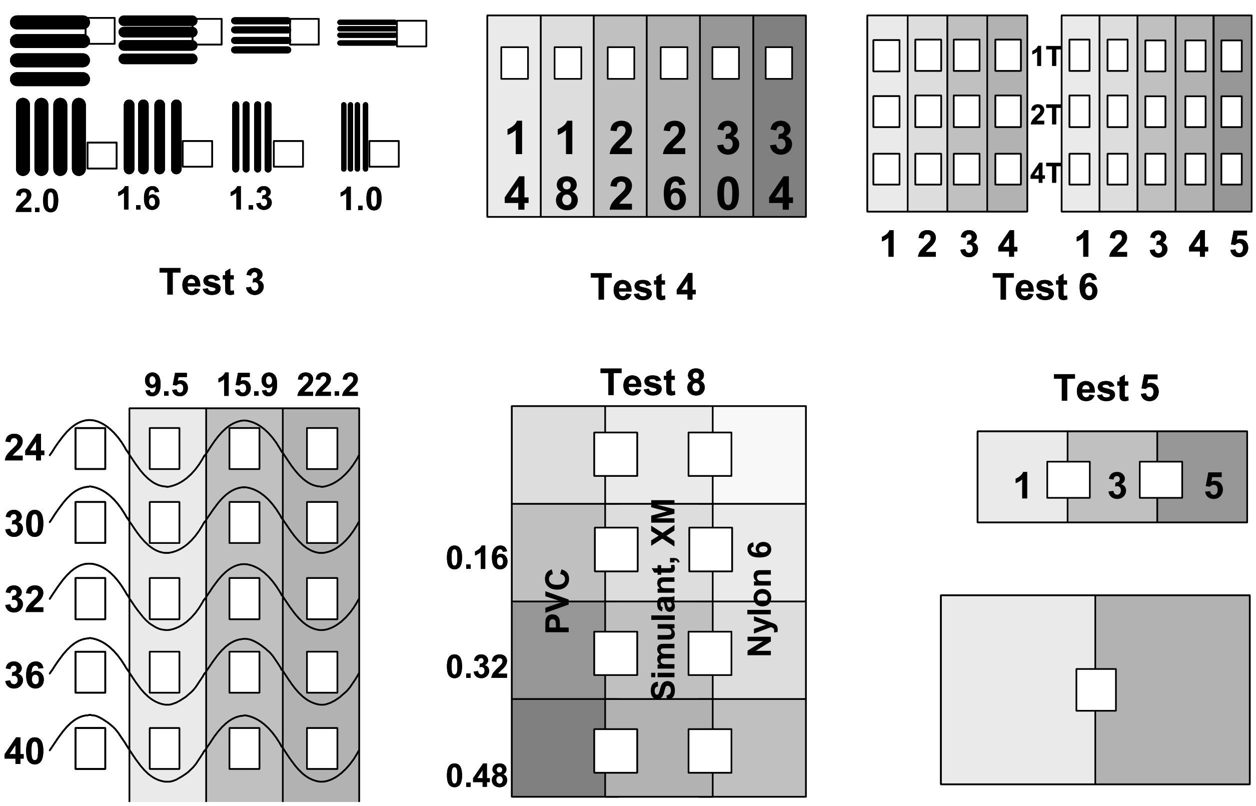
Test	Image enhancement features used
1. Wire display	
2. Useful penetration	
3. Wire resolution	
4. Simple penetration	
5. Thin organic imaging	
6. IQI sensitivity	
7. Inorganic/organic differentiation	
8. Organic differentiation	
9. Useful organic differentiation	

Test-Object Imaging-Performance Check Form



ANSI N42.44 Imaging-Test Results Summary

Doc. Ref. #:______________, Page 3 of 4

(If system does not claim organic differentiation, place NA in Test results and Pass columns)

Test	Description	Minimum requirement, Largest tunnel dimension: <70 cm	Minimum requirement, Largest tunnel dimension: ≥70 cm	Test results	Pass (✓)
1	Wire display:				
	Smallest wire under 0 mm Al	32 AWG	32 AWG		
2	Useful penetration:				
	Smallest wire under 9.5 mm Al	30 AWG	30 AWG		
	Smallest wire under 15.9 mm Al	30 AWG	24 AWG		
	Smallest wire under 22.2 mm Al	30 AWG	24 AWG		
3	Vertical wire resolution:	1.6 mm	1.6 mm		
	Horizontal wire resolution:	1.6 mm	1.6 mm		
4	Simple penetration (steel):	22 mm	22 mm		
5	Thin organic imaging:				
	Distinguish 1 mm and 3 mm	Yes	Yes		
	Distinguish 3 mm and 5 mm	Yes	Yes		
6	IQI sensitivity (smallest discerned):				
	Delrin®[a] (plastic): 4T	3 (9.6 mm)	4 (12.8 mm)		
	2T	4 (6.4 mm)	4 (6.4 mm)		
	1T	No minimum	No minimum		
	Steel: 4T	No minimum	No minimum		
	2T	No minimum	No minimum		
	1T	No minimum	No minimum		
7[b]	Inorganic/organic differentiation:	Yes	Yes		
8[b]	Organic differentiation:				
	0 mm steel: PVC/XM®[c]	Yes	Yes		
	XM®/nylon	Yes	Yes		
9[b]	Useful organic differentiation:				
	1.6 mm steel: PVC/XM®	Yes	Yes		
	XM®/nylon	Not required	Not required		
	3.2 mm steel: PVC/XM®	Not required	Not required		
	XM®/nylon	Not required	Not required		
	4.8 mm steel: PVC/XM®	Not required	Not required		
	XM®/nylon	Not required	Not required		

[a] Delrin is a registered trademark of E.I. Du Pont de Nemours and Company Corporation. This information is given for the convenience of users and does not constitute an endorsement by the IEEE of these products. Equivalent products may be used if they can be shown to lead to similar results.

[b] Not required for systems without organic and inorganic differentiation.

[c] XM is a division of Van Aken International. For purposes of this table, XM represents the TNT stimulant XM-02-X manufactured by the XM Division of Van Aken International, Rancho Cucamomga, CA. This information is given for the convenience of users and does not constitute an endorsement by the IEEE of these products. Equivalent products may be used if they can be shown to lead to similar results.

ANSI N42.44 X-Ray Exposure Measurement Results

Doc. Ref. #:______________, Page 4 of 4

Tester:	Place:	Date/time:
X-Ray system manufacturer:	Model:	Serial #:

Instrument Used for Exposure-of-Contents Measurements

Manufacturer:	Model:	Serial #:
Calibration date:		

Requirement: < 8.76 μGy (< 1 mR) in a Single Scan

Test conditions	**Parameter settings (x-ray tube kV and mA; belt speed)**	**Measurement result**	**Pass (✓)**
Maximum exposure[a]			
Routine exposure[b]			
Optional scan			
Optional scan			

[a] Pertains to parameter settings that produce the maximum air kerma or exposure in a scan.
[b] Pertains to parameter settings for routine screening.

Annex B

(informative)

Human-factors engineering considerations

Screening performance is a function of both the system imaging performance and the operator performance. Operator performance can be enhanced by more optimal engineering of the controls and display of the system. Commonality of features can simplify operator training and help avoid confusion, particularly for large-scale screening applications involving multiple system manufacturers. Many important human-factors considerations can be identified for standardization. Some of the most important are included in this annex. Without question many of these have a direct, if unquantifiable, bearing on screening performance. Defined testing procedures are not proposed for the human-factors considerations in this document.

Human-factors issues considered to be most important for screening performance are indicated below.

Full functionality for operators meeting personnel requirements is specified in the TSA Code of Federal Regulations, Title 49, Part 1544.

The operator control panel (OCP) should provide x-ray image-analysis tools (e.g., organic/inorganic stripping, magnification, inverse imaging) for the screener/operator to enhance the displayed image. The displays should provide good resolution and color saturation to enable the operator to discern common and familiar objects. The system manufacturer should follow the human factors guidelines found in Chapter 7 and Chapter 8 of the Federal Aviation Administration Technical Report DOT/FAA/CT-96/1 and in the revision to Chapter 8 (DOT/FAA/CT-01/08). Specific considerations should address the following:

— Displays should indicate system status, threat resolution, bag jams, and faulty image events.
— System should respond to inputs by the operator in 1 s or less.
— OCP and display icons, symbols, and abbreviations should be intuitive and easily recognized, with minimum character height of 2.3 mm (0.1 in) or larger; preferred height would be 2.9 mm to 3.3 mm (0.116 in to 0.128 in).
— Text labels, system actions, and feedback should be placed in close proximity to the event with which they are associated.
— Display image should follow a color and grayscale look-up table such that all manufacturers use a universal color scheme to represent density, inorganic, organic, and heavy metals.
— Function keys and icons preferably should be assigned a single function. If a function key or icon has multiple functions, the system should display which function is activated.
— Use of embedded menu systems or multi-step processes should be intuitive and follow conventional patterns of use.