



American National Standard for Measuring the Imaging Performance of X-ray and Gamma-ray Systems for Security Screening of Humans

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42

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Secretariat

Institute of Electrical and Electronics Engineers, Inc.

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Abstract: This standard applies to security screening systems that utilize x-ray or gamma radiation and are used to inspect people who are not inside vehicles, containers, or enclosures. Specifically, this standard applies to systems used to detect objects carried on or within the body of the individual being exposed. The purpose of this standard is to provide standard methods of measuring and reporting imaging quality characteristics and establish minimum acceptable performance requirements.

Keywords: body scanner, gamma-ray, imaging performance, materials detection, minimum requirements, penetration, personnel scanner, security screening, spatial resolution, wire detection, x-ray

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1. Overview

This document establishes standard test methods and test devices for measuring the imaging performance of x-ray and gamma-ray systems for security screening of humans. Minimum acceptable performance requirements are also provided. The procedures and minimum acceptable requirements in this standard should not be construed as an all-inclusive measure of performance for any situation. Depending on the circumstances and detection needs, user institutions will continue to generate their own requirements and are encouraged to do so. Rather, it is hoped that this standard will provide a starting point for evaluating systems, provide a uniform set of readily available information to compare equipment, and offer a standard procedure for periodic quality control testing.

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 the systems covered. These include: electromagnetic compatibility, and radiological, electrical, and mechanical safety.

Three annexes are included. Annex A (normative) provides mechanical drawings of the imaging test objects. Sample test report forms are given in Annex B (informative). Annex C (informative) provides a generic description of the pentolith—the spatial resolution test object developed for this standard.

1.1 Scope

This standard applies to security screening systems that utilize x-ray or gamma radiation and are used to inspect people who are not inside vehicles, containers, or enclosures. Specifically, this standard applies to systems used to detect objects carried on or within the body of the individual being exposed.

The following types of systems are included in the scope of this standard:

- Systems designated as fixed, portal, re-locatable, transportable, mobile, or gantry.
- Systems employing detection of primary radiation (transmission systems), or scatter radiation (backscatter systems), or a combination of both.
- Systems that are primarily imaging but that also may have complementary features such as material discrimination, or automatic active or passive threat alerts. This standard will not address how to test these complementary features.

1.2 Purpose

The purpose of this standard is to provide standard methods of measuring and reporting imaging quality characteristics and to establish minimum acceptable performance requirements for the systems described in 1.1.

2. Normative references

The following normative documents contain provisions that, through reference in Clause 4 of this standard, constitute requirements of this standard. For dated references or those with specified editions, subsequent amendments or revisions do not apply. For undated references, the latest edition of the normative document referred to applies. Users of this standard should note that standards referenced herein may not fulfill the legal requirements and practices in all states, countries, or jurisdictions. Care should be taken to ensure regulatory compliance.

ANSI/HPS N43.17, Radiation Safety for Personnel Security Screening Systems Using X-ray or Gamma Radiation.¹

ASME B20.1, Safety Standard for Conveyors and Related Equipment (only for systems employing conveyors).²

CISPR 11, Industrial, scientific and medical (ISM) Radio-frequency equipment disturbance characteristics—Limits and methods of measurement, Edition 5.0, 2009-05.³

Code of Federal Regulations, Title 47— Part 15 (47 CFR 15), Telecommunications, Chapter I—Federal Communications Commission, Part 15—Radio Frequency Devices.⁴

¹ Available from Health Physics Society, Health Physics Society, 1313 Dolley Madison Boulevard, Suite 402, McLean, VA 22101, USA (<http://www.hps.org>), or from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

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 CISPR documents are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, 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, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA.

Code of Federal Regulations, Title 47— Part 18 (47 CFR 18) Telecommunications, Chapter I—Federal Communications Commission, Part 18—Industrial, Scientific, and Medical Equipment.

IEC 60204-1, Safety of machinery—Electrical equipment of machines—Part 1: General requirements.⁵

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, radiofrequency, 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 and/or UL 61010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use—Part 1: General requirements.

3. Definitions and special terms

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be referenced for terms not defined in this clause.⁶

backscattered radiation (also backscatter): Radiation deflected at angles greater than 90° from the initial direction of travel.

backscatter system: A security screening system that makes use of backscattered radiation to form an image.

⁴ CFR publications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, USA (<http://www.access.gpo.gov/>).

⁵ IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, Case postale 131, CH-1211 Geneva 20, Switzerland (<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.

⁶ *The IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at <http://shop.ieee.org/>.

contrast sensitivity: The ability to discern a change in the thickness of an otherwise uniform material as a change in brightness in the x-ray or gamma-ray image.

edge detection: The ability to discern edges of objects or anomalies even when the bulk of the objects or anomalies may appear with the same brightness as the background.

mobile system: A system that is mounted on a vehicle that moves while scanning.

operator: The person who controls the activation and adjustment of the imaging system and interprets the image.

partial body field of view: The field of view of systems designed to scan parts of the body, such as cast and prostheses scanners or shoe scanners.

primary radiation: Radiation coming directly from the radiation source to the detector without being scattered.

radiation source: The location from which radiation emanates (e.g., the anode of an x-ray tube or the radioactive material employed).

relocatable system: A system that is mounted on a vehicle for ease of deployment at different locations. The system normally requires some setting up at the location of use and is stationary while scanning.

scan area: The field of view of a screening system at a given distance from the source of radiation.

scan speed: The speed at which the radiation beam and object to be imaged move relative to each other.

scattered radiation (also scatter): Radiation deflected from a straight or direct path by intervening material.

security screening: The non-destructive inspection of personal goods, cargo, vehicles, and other objects to detect prohibited, controlled, or dangerous items. In the case pertaining to this standard the objects inspected are carried on or within the body of a person.

spatial resolution: The minimum separation between two objects for which objects with widths equal to the separation can be distinguished as separate entities.

transmission system: A system using the conventional means of radiographic imaging in which x rays or gamma rays pass through a target (e.g., person or container) and create shadow-grams of enclosed objects (e.g., contraband) based on their radiation attenuating properties.

transportable system: A system that is designed to be easily redeployed and transported.

whole body field of view: The field of view of systems designed to completely scan and image one person at a time.

wide field of view: The field of view of systems for which one scan covers an area that may contain more than one person.

wire detection test: A test to determine the smallest diameter wire that can be detected through the use of a given imaging system.

3.2 Special terms

In this standard, the following special terms and definitions apply.

pentalith: a spatial resolution test object designed for this standard. The pentalith consists of five equal spheres placed at the vertices of a regular pentagon. The space between the spheres is equal to the sphere diameter. (See 5.5 for a complete description).

reference location: a required location where test objects are placed for assessing imaging performance according to this standard. The reference location is specified in 5.3. Other testing locations may be used for additional information.

system: In the context of this standard, a security screening system that uses x-ray or gamma radiation and is utilized to inspect people.

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 of the system, 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

To provide for 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 °C ± 5 °C (71.6 °F ± 9.0 °F)
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

Systems shall comply with the requirements of ANSI/HPS N43.17, Radiation Safety for Personnel Security Screening Systems Using X-ray or Gamma Radiation.

4.4 Electrical and mechanical safety

Screening systems shall meet the following existing fire, electrical, and mechanical safety requirements of the indicated standards:

- a) IEC 61010-1 and/or UL 61010-1
- b) IEC 60601-2-28 (1993), as noted below:
 - 1) Products having a high-voltage cable external to the high-voltage assembly shall comply with Clause 16, Enclosures and protective covers.
 - 2) Products having field-replaceable x-ray tubes shall comply with Subclauses 45.2 and 45.7, Pressure vessels and parts subject to pressure.
- c) ASME B20.1 and/or IEC 60204-1

4.5 Electromagnetic compatibility

Systems shall meet the following electromagnetic compatibility requirements of the indicated regulations or standards. Subclauses 4.5.3, 4.5.4, 4.5.5, 4.5.6, 4.5.7, and 4.5.8 specify testing parameters to be used in conjunction with the indicated IEC 61000 testing standards. Performance criteria pertaining to the requirements listed in Subclauses 4.5.3, 4.5.4, 4.5.5, 4.5.6, 4.5.7, and 4.5.8 below are classified in Table 2.