# IEC 62709

Edition 2.0 2024-09

# INTERNATIONAL STANDARD

colour inside

## Radiation protection instrumentation – Security screening of humans – Measuring the imaging performance of X-ray systems



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## Radiation protection instrumentation – Security screening of humans – Measuring the imaging performance of X-ray systems

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# RADIATION PROTECTION INSTRUMENTATION – SECURITY SCREENING OF HUMANS – MEASURING THE IMAGING PERFORMANCE OF X-RAY SYSTEMS

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IEC 62709 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation. It is an International Standard.

This second edition cancels and replaces the first edition published in 2014. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Clarified the test procedures to maintain consistency with IEC 62463.
b) Changed the term "spatial resolution" to "pentalith resolution".
c) Modified some standard test conditions.
d) Modified some terms and definitions.
e) Changed the imaging requirements for transmission general-use systems.

The text of this International Standard is based on the following documents:

| Draft | Report on voting |
|---|---|
| 45B/1059/FDIS | 45B/1069/RVD |

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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# INTRODUCTION

This document establishes standard test methods and test objects for measuring the imaging performance of X-ray systems for security screening of humans. For each image quality test, this document also sets minimum acceptable levels of performance. These procedures and minimum acceptable requirements 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 document 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.

Four 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 pentalith resolution test object. Annex D (informative) seeks to describe the different types of security systems presently being used for whole-body imaging.

# RADIATION PROTECTION INSTRUMENTATION – SECURITY SCREENING OF HUMANS – MEASURING THE IMAGING PERFORMANCE OF X-RAY SYSTEMS

## 1 Scope

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

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

– Systems designated as mobile or fixed.
– Systems employing detection of primary radiation, backscattered radiation, forward-scattered radiation, (see Annex D) or some combination of these modalities to form two-dimensional X-ray images.
– Systems that are primarily imaging but that also may have complementary features such as material discrimination, automatic active or passive detection alerts. This document does not address how to test these complementary features.

The objective is to provide standard methods of measuring and reporting imaging quality characteristics that enable system manufacturers, potential system users and other interested parties to:

a) Establish a consistent indicator of the expected technical performance of screening systems used for the inspection of individuals. Such technical performance testing complements explicit detection testing and evaluation. In this document "detection" refers to items in an image.
b) Provide repeatable and verifiable imaging performance data that can be used to compare systems from different vendors.
c) Establish a baseline that can be used over time to calibrate the system or detect any performance degradation. (It is not intended that the entire test method be employed for daily quality assurance testing.)
d) Establish minimum acceptable performance requirements for the systems described above.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-395:2014, *International Electrotechnical Vocabulary (IEV) – Part 395: Nuclear instrumentation – Physical phenomena, basic concepts, instruments, systems, equipment and detectors*
IEC 60050-395:2014/AMD1:2016
IEC 60050-395:2014/AMD2:2020

IEC 60050-881:1983, *International Electrotechnical Vocabulary (IEV) – Part 881: Radiology and radiological physics*
IEC 60050-881:1983/AMD1:2014
IEC 60050-881:1983/AMD2:2019
IEC 60050-881:1983/AMD3:2020

IEC 62463:2024, *Radiation protection instrumentation – X-ray systems for the security screening of persons*

ISO 683-17:2023, *Heat-treatable steels, alloy steels and free-cutting steels – Part 17: Ball and roller bearing steels*

## 3 Terms, definitions, abbreviated terms, quantities and units

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

### 3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply. The general terminology concerning X-ray systems and radiological physics is given in IEC 60050-395:2014 and IEC 60050-881:1983.

**3.1.1**
**backscattered radiation**
**backscatter**
scattering of photons by material through angles greater than 90°with respect to their initial direction

**3.1.2**
**backscatter system**
security screening system that makes use of backscattered radiation to form an image

**3.1.3**
**body phantom**
object whose absorption and scattering effects on ionizing radiation are equivalent to a human

**3.1.4**
**contrast sensitivity**
ability to distinguish a small difference of intensity in an area of an X-ray image from a surrounding uniform background

[SOURCE: IEC 62523:2010, 3.11]

**3.1.5**
**edge detection**
ability to discern edges of objects or anomalies even when the bulk of the objects oranomalies may appear with the same brightness as the background

**3.1.6**
**effective dose**
dose quantity intended to reflect the stochastic health risk to the whole body due to radiation exposure. It is calculated based on the sum of the equivalent doses in various organs multiplied by the appropriate tissue weighting factors

**3.1.7**
**forward-scattered radiation**
**forward-scatter**
scattering of photons by material through angles less than 90°with respect to their initial direction

**3.1.8**
**forward-scatter system**
security screening system that makes use of forward-scattered radiation to form an image

**3.1.9**
**floor of the scanner**
surface that individuals stand on when scanned

**3.1.10**
**general-use system**
X-ray screening system that is configured to deliver an effective dose of less than 0,25 µSv per screening (using the dose estimation methods defined in IEC 62463) and operating using the administrative controls specified in IEC 62463. Given proper justification and certain restrictions, general-use systems may be operated without specific controls that would limit the number of individuals scanned or the number of scans per individual in a year

Note 1 to entry: This definition was reproduced, with the permission of the Health Physics Society (HPS), from ANSI/HPS N43.17-2009 (R2018)

[SOURCE: IEC 62463:2024, 3.4]

**3.1.11**
**influence quantity**
quantity that is not the measurand but that affects the result of the measurement

**3.1.12**
**limited-use system**
personnel screening system that is configured to deliver an effective dose that does not exceed 10 µSv per screening (using the dose estimation methods defined in IEC 62463) which does not meet the definition of a general-use system. Limited-use systems require additional controls and documentation to ensure that annual individual dose limits are not exceeded.

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[SOURCE: IEC 62463:2024, 3.7]

**3.1.13**
**materials detection**
test of the ability to detect materials on or off the body phantom

**3.1.14**
**operator**
person that controls one or more aspects of the screening procedure. An operator is authorized to perform their duties, appropriately trained, and performs their duties according to the standard operating procedure

[SOURCE: IEC 62463:2024, 3.9]

**3.1.15**
**partial body field of view**
field of view of systems designed to scan parts of the body, such as cast and prostheses scanners or shoe scanners

**3.1.16**
**penetration test**
test of pentalith resolution and wire detection as a function of body phantom thickness

**3.1.17**
**pentalith**
resolution test object consisting of five equal spheres placed at the vertices of a regular pentagon. The vertices are separated by twice the diameter of the spheres

Note 1 to entry: See Annex C for a complete description.

**3.1.18**
**pentalith resolution**
minimum separation between two spherical objects at which they can be resolved as separate entities, as measured using the pentalith test

**3.1.19**
**primary radiation**
ionizing radiation emitted by a radiation source which has not undergone scattering

**3.1.20**
**radiation source**
equipment or matter emitting or capable of emitting ionizing radiation

**3.1.21**
**reference location**
required location where test objects are placed for assessing imaging performance according to this document

Note 1 to entry: The reference location is specified in 4.2.

Note 2 to entry: Other testing locations may be used for additional information.

**3.1.22**
**Screening procedure**
Procedure, described in the SOP, that is followed to completely inspect something using the X-ray system

Note 1 to entry: Depending on the concept of operation of the system, this could involve taking multiple scans.

[SOURCE: IEC 62463:2024, 3.17]

**3.1.23**
**scan area**
field of view of a screening system at a given distance from the source of radiation

**3.1.24**
**scanning speed**
speed of the inspected object moving relative to the inspection system, or vice versa

[SOURCE: IEC 62523:2010, 3.15]

**3.1.25**
**scattered radiation**
**scatter**
radiation which, during passage through a material, has been deviated from its original direction or changed in energy by scattering

Note 1 to entry: Backscatter and forward-scatter systems use scatter to form backscatter and/or forward-scatter images.

[SOURCE: IEC 60050-881:1983,881-03-19]

**3.1.26**
**security screening**
inspection of personnel, goods, cargo, vehicles and other objects to detect prohibited, controlled or dangerous items

Note 1 to entry: In the case of this document, the objects inspectedare carried on or within the body of a person.

**3.1.27**
**system**
**scanning system**
equipment used to produce a scanned image, including the X-ray generator, collimator, detector assembly, computer and display console

**3.1.28**
**transmission system**
system using the conventional means of projection radiographic imaging in which X rays pass through a target (e.g., person or container) and create shadowgrams of enclosed objects (e.g., contraband) based on their radiation attenuating properties

**3.1.29**
**whole body field of view**
field of view of systems designed to completely scan and image a person in one image

**3.1.30**
**wide field of view**
field of view of systems for which one scan covers an area that may contain more than one person

**3.1.31**
**wire detection**
minimum diameter of a wire in mm, that can be detected and distinguished from the background

[SOURCE: IEC 62523:2010, 3.10]

### 3.2 Abbreviated terms

HDPE high-density polyethylene

### 3.3 Quantities and units

In this document, the units are the multiples and sub-multiples of units of the International System of Units(SI)[1]. The definitions of radiation quantities are given in IEC 60050-395.

## 4 Imaging performance evaluation procedures

### 4.1 General characteristics and test procedures

The procedures of this document shall be used to measure the following four characteristics of imaging performance or image quality:

a) Pentalith resolution.

b) Wire detection.

c) Materials detection (may be by means of contrast sensitivity or edge detection).

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1 International Bureau of Weights and Measures: The International System of Units, 8th edition, 2006.