IEC 62709

Edition 1.0 2014-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Instrumentation pour la radioprotection – Contrôle de sécurité des individus – Mesure des performances de l'imagerie des systèmes radiographiques aux rayons X

IEC 62709:2014-02(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 14 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 55 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 14 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
Plus de 55 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 62709

Edition 1.0 2014-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Instrumentation pour la radioprotection – Contrôle de sécurité des individus – Mesure des performances de l'imagerie des systèmes radiographiques aux rayons X

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX W

ICS 13.280

ISBN 978-2-8322-1422-0

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

The text of this standard is based on the following documents:

FDIS	Report on voting
45B/780/FDIS	45B/786/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This standard 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 standard 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 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.

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, the spatial 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 and object

This International Standard 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 standard applies to systems used to detect objects carried on or within the body of the individual being inspected. This standard does not include requirements related to electromagnetic compatibility, radiological, electrical and mechanical safety. These requirements are covered in IEC 62463:2010.

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

- Systems designated as fixed, portal, transportable, mobile or gantry.
- 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 standard will 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 standard “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, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE Users of this standard should note that standards referenced herein may not fulfil the legal requirements and practices in all countries, or jurisdictions. Care should be taken to ensure regulatory compliance.

IEC 60050-393:2003, *International Electrotechnical Vocabulary (IEV) – Part 393: Nuclear instrumentation – Physical phenomena and basic concepts*

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

IEC 60050-881:1983, *International Electrotechnical Vocabulary (IEV) – Part 881: Radiology and radiological physics*

IEC 62463:2010, *Radiation protection instrumentation – X-ray systems for the screening of persons for security and the carrying of illicit items*

ISO 683-17:1999, *Heat-treated steels, alloy steels and free-cutting steels – Part 17: Ball and roller bearing steels*

3 Terms and definitions, abbreviations, quantities and units

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 60050-393:2003, IEC 60050-394:2007 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

[SOURCE: IEC 60050-393:2003, 393-13-14]

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

3.1.3
contrast sensitivity
the 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]

3.1.4
edge detection
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

3.1.5
forward-scattered radiation
scattering of photons by material through angles less than 90° with respect to their initial direction

3.1.6
forward-scatter system
security screening system that makes use of forward-scattered radiation to form an image

3.1.7
influence quantity
quantity that is not the measurand but that affects the result of the measurement

[SOURCE: IEC 60050-394:2007, 394-40-27]

3.1.8
materials detection
test of the ability to detect materials on or off the body phantom

3.1.9
mobile system
system that is mounted on a vehicle which moves while scanning

3.1.10
operator
person authorised and fully trained to operate the system

[SOURCE: IEC 62463:2010]

3.1.11
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

3.1.12
penetration test
test of spatial resolution and wire detection as a function of body phantom thickness

3.1.13
pentalith
spatial 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.

3.1.14
primary radiation
ionizing radiation emitted directly by a radiation source

[SOURCE: IEC 60050-393:2003, 393-12-19]

3.1.15
radiation source
equipment or matter emitting or capable of emitting ionizing radiation

[SOURCE: IEC 60050-393:2003, 393-12-23]

3.1.16
reference location
required location where test objects are placed for assessing imaging performance according to this standard

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.

3.1.17
scan area
field of view of a screening system at a given distance from the source of radiation

3.1.18
scanning speed
the speed of the inspected object moving relative to the inspection system, or vice versa

[SOURCE: IEC 62523:2010]

3.1.19
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]

3.1.20
security screening
inspection of personnel, 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

3.1.21
spatial resolution
minimum separation between two objects at which they can be resolved as separate entities

3.1.22
system
scanning system
whole equipment used to produce a scanned image, including the X-ray generator, collimator, detector assembly, computer and display console

3.1.23
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

3.1.24
transportable system
system that is designed to be easily redeployed and transported

3.1.25
whole body field of view
field of view of systems designed to completely scan and image one person at a time

3.1.26
wide field of view
field of view of systems for which one scan covers an area that may contain more than one person

3.1.27
wire detection
the minimum diameter of a wire in mm, that can be detected and distinguished from the background

[SOURCE: IEC 62523:2010]

3.2 Abbreviations

3.2.1
HDPE
high-density polyethylene

3.2.2
MTF
modulation transfer function

3.3 Quantities and units

In this standard, 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 60050-393 and IEC 60050-394.

4 Imaging performance evaluation procedures

4.1 General characteristics and test procedures

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

a) Spatial resolution

b) Wire detection

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

d) Penetration

The test procedures provide for the measurement of systems that use the following imaging modes: detection of primary radiation, backscattered radiation, forward-scattered radiation, or some combination of these modalities (see Annex D).

For each test, the test object shall be scanned as in normal use; this is defined to mean standard operating procedure, software, and hardware settings of lateral and/or vertical scan speed, source voltage and current, and filtration. Since dose to scanned individuals and image quality are interrelated, these machine settings shall be included in the test report (for an example, see Annex B). If the dose to scanned persons is also being measured (e.g., IEC 62463:2010) for this system, the same machine settings should be used for both the image quality and radiation safety testing to facilitate the assessment of overall system performance. If image-enhancement software features are available to the operator in normal use, these may be used to achieve the best possible image. Examples are zoom, edge enhancement, expanded density, black-and-white reverse, and pseudo-color. The use of these software features shall be recorded in test documentation in addition to the hardware settings listed above.

The score for each test shall be repeatable at least two thirds of the time.

4.2 Location of testing

At a minimum, all the image quality tests shall be performed at the reference location. The reference location is defined as follows:

a) the surface of the body phantom and test object combination closest to the radiation source shall be at the optimum operating distance as specified by the manufacturer, and

---

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

b) the centre of the body phantom shall be in the lateral centre of the scan area and, for full-body systems, at a height 1 m from the ground. For partial body systems the reference location should be centred about the subject imaging location. A generic illustration of this testing configuration is given in Figure 1.

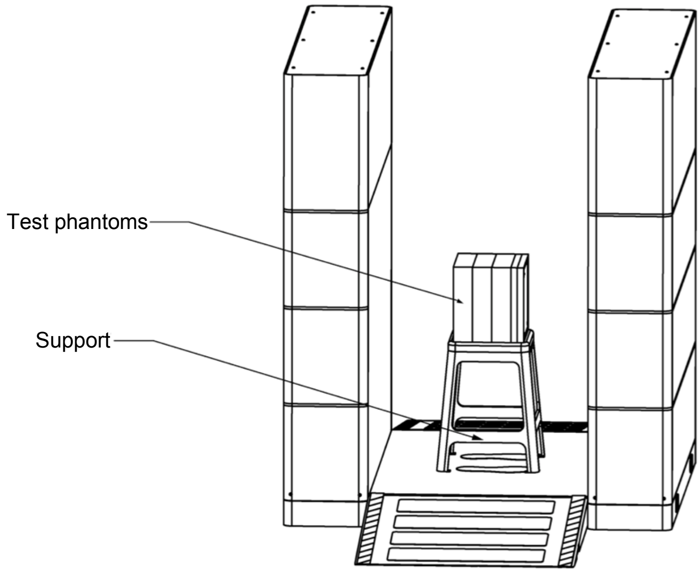


Figure 1 – Generic illustration of the testing configuration showing a HDPE body phantom with a test object on one end supported 1 m off the ground

Additionally, off-centre tests should be performed at specified locations. Prospective users may request test results for specific locations in the scan area (e.g. head, feet, sides, edge of scan area). For off-centre tests, a 300 mm × 300 mm × 100 mm block of high-density polyethylene (HDPE) may be placed in the centre of the field of view if needed for proper functioning of the auto gain control.

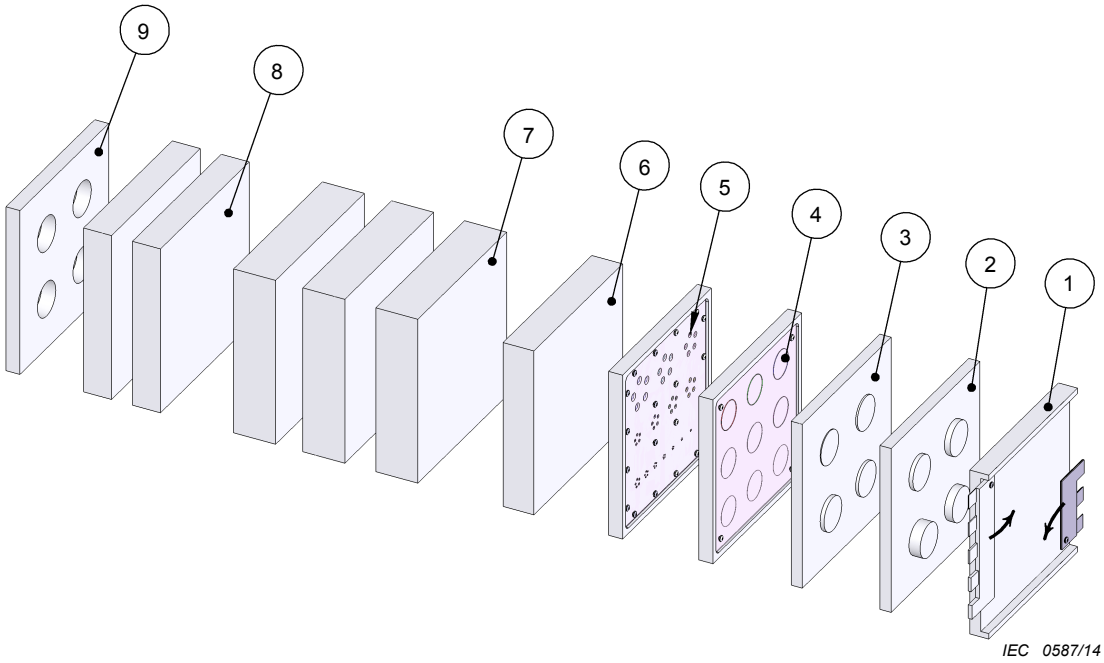
4.3 Body phantom and test objects

The test objects for each of the image quality tests shall be mounted on a body phantom. The body phantom shall be made of HDPE. The body phantom and all the other HDPE parts of test objects described in this standard shall have a density of 0,95 g·cm^{-3} ± 0,05 g·cm^{-3}.

The body phantom shall have dimensions of 300 mm wide × 300 mm high × 280 mm deep. The body phantom shall have a means of supporting each of the test object assemblies described in 4.4 through 4.7 so that the overall HDPE depth of the body phantom and test object assembly (excluding the 1,5 mm overlay) shall be 300 mm. That is, a HDPE cube, 300 mm on each side, is used to simulate the human body.

For the penetration test the overall depth shall be expandable from 300 mm to 400 mm by attaching two additional 50 mm thick slabs of HDPE. A diagram of the body phantom and test objects is shown in Figure 2. Complete mechanical drawings of the body phantom and test objects are provided in normative Annex A.

All the dimensions of the body phantom and test objects shall be within ±2 % or 0,2 mm, whichever is greater, unless otherwise specified.



Key

1	materials detection in air
2 and 3	materials detection on body
4	wire detection
5	spatial resolution
6 and 7	body phantom, four pieces
8	penetration test, two pieces
9	storage spacer

NOTE For each test the respective test object, (1) through (5), is placed over the four body phantom pieces, (6) and (7). The body phantom extensions, (8), are used for the penetration test. The last piece, (9), is only a spacer used for storing and stacking pieces (2) and (3) with the other blocks. The combs of piece (1) swivel inward for storage.

Figure 2 – Body phantom and test objects

4.4 Spatial resolution test

4.4.1 Purpose

The purpose of this test is to measure the ability to distinguish as separate, objects that are themselves separated by a space equal to the object width.

4.4.2 Test object description

The spatial resolution test object consists of fourteen sets of five equal spheres, forming fourteen regular pentagons, called pentaliths (see also informative Annex C). The spheres are made of bearing steel, ISO 683-17:1999, grade designation 100Cr6 or equivalent (e.g. AISI/SAE 52100, EN 10027-2 1.3505; JIS SUJ2) and are imbedded in a block of HDPE, 300 mm × 300 mm × 25 mm, so that the front surface of each sphere is flush with the surface of the block. The five spheres are placed at the vertices of a regular pentagon. The space between adjacent spheres is equal to the sphere diameter. Each pentagon is aligned such that no side is perfectly vertical or horizontal. There is a pentagon for each of the following sphere diameters: 1 mm, 1,2 mm, 1,5 mm, 2 mm, 2,5 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 10 mm, 12 mm, and 14 mm. The tolerance for each sphere diameter and the hole containing each sphere shall be no greater than ±0,1 mm. A 1,5 mm thick sheet of HDPE is placed over the spheres to simulate a layer of thick clothing and to hold the spheres in place.