

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Radiation protection instrumentation – Measuring the imaging performance of X-ray computed tomography (CT) security-screening systems

Instrumentation pour la radioprotection – Mesure des performances d'imagerie des systèmes de contrôle de sécurité utilisant la tomographie par ordinateur (CT) à rayons X



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2018 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

Tel.: +41 22 919 02 11
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 - webstore.iec.ch/advsearchform

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 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 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: sales@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 -

webstore.iec.ch/advsearchform

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 21 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 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: sales@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



Radiation protection instrumentation – Measuring the imaging performance of X-ray computed tomography (CT) security-screening systems

Instrumentation pour la radioprotection – Mesure des performances d'imagerie des systèmes de contrôle de sécurité utilisant la tomographie par ordinateur (CT) à rayons X

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 13.280

ISBN 978-2-8322-6025-8

**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

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references.....	9
3 Terms and definitions, abbreviated terms, quantities and units	9
3.1 Terms and definitions	9
3.2 Abbreviated terms	12
3.3 Quantities and units	2
4 Imaging performance evaluation procedures	12
4.1 General test performance requirements	12
4.2 Description of test articles	13
4.3 Manually recorded data	16
4.3.1 Purpose	16
4.3.2 System data.....	16
4.3.3 Evaluation environment data	18
4.3.4 Comments	18
4.3.5 Deviations from specified methods	18
4.3.6 Presentation of results	19
4.4 Object length accuracy	20
4.4.1 Purpose	20
4.4.2 Test object description	21
4.4.3 Test method.....	21
4.4.4 Presentation of results	23
4.5 Path-length CT value and Z_{eff}	24
4.5.1 Purpose	24
4.5.2 Test object description	24
4.5.3 Test method.....	25
4.5.4 Presentation of results	26
4.6 Noise equivalent quanta (NEQ)	26
4.6.1 Purpose.....	26
4.6.2 Test object description	27
4.6.3 Test method.....	27
4.6.4 Presentation of results	29
4.7 CT value consistency	30
4.7.1 Purpose	30
4.7.2 Test object description	30
4.7.3 Test method.....	30
4.7.4 Presentation of results	30
4.8 CT value uniformity and x-ray energy spectrum consistency.....	30
4.8.1 Purpose	30
4.8.2 Test object description	31
4.8.3 Test method.....	31
4.8.4 Presentation of results	32
4.9 Streak artifacts.....	33
4.9.1 Purpose	33
4.9.2 Test object description	33

4.9.3	Test method.....	33
4.9.4	Presentation of results	34
4.10	Slice sensitivity profile (SSP).....	35
4.10.1	Purpose.....	35
4.10.2	Test object description	35
4.10.3	Test method.....	35
4.10.4	Presentation of results	36
4.11	Image registration	36
4.11.1	Purpose.....	36
4.11.2	Test object description	36
4.11.3	Test method.....	37
4.11.4	Presentation of results	40
5	Environmental requirements.....	40
Annex A (normative)	Detailed test article specifications and drawings.....	41
A.1	General.....	41
A.2	Commercial parts.....	41
A.3	Outer enclosure	41
A.4	Detailed drawings of custom components	42
Annex B (informative)	Example of reporting format	66
B.1	General.....	66
B.2	Example report.....	66
Annex C (informative)	Statistical guidance on multiple scans, summary statistics, and comparison of results.....	70
C.1	General.....	70
C.2	Scenario A: Comparing a single CT system between its baseline and candidate (revised) configuration.....	70
C.3	Scenario B: Comparing a single candidate system against an existing historical population of systems.....	71
Bibliography	72
Figure 1	– Reference axes for testing procedures.....	13
Figure 2	– Test article A.....	14
Figure 3	– Test article B.....	15
Figure 4	– Format example for manually recorded data.....	20
Figure 5	– Object length test object.....	21
Figure 6	– Output from object length procedure when test article is submitted within angular tolerance.....	24
Figure 7	– Output from object length procedure when test article rotation is outside of angular tolerance.....	24
Figure 8	– Path-length test object.....	25
Figure 9	– Example plot of path-length test results	26
Figure 10	– NEQ test object	27
Figure 11	– Z uniformity test object and streak artifact test object	31
Figure 12	– Pins in test object axial slice (large circle), midpoints between neighboring pin pairs (small circles), traced line, and rectangular ROI.....	33
Figure 13	– Slanted edge test object used to measure z resolution	35
Figure 14	– Registration test object (not to scale)	37

Figure 15 – CT image of registration test object, slice plane 1.....	38
Figure 16 – Horizontal line profile through CT slice of the registration test object	38
Figure 17 – Projection image of the registration test object and vertical profile through image.....	39
Figure A.1 – Assembly of Case A test article	43
Figure A.2 – Assembly of Case B test article	44
Figure A.3 – Test component sub-assembly of Case A test article (drawing 1 of 2).....	45
Figure A.4 – Test component sub-assembly, Case A test article (drawing 2 of 2).....	46
Figure A.5 – Test component sub-assembly, Case B test article (drawing 1 of 2).....	47
Figure A.6 – Test component sub-assembly, Case B test article (drawing 2 of 2).....	48
Figure A.7 – Sub-components for Case A cylinder test object	49
Figure A.8 – Ring sub-components for Case A cylinder test object.....	50
Figure A.9 – Pin sub-components for Case A cylinder test object (streak artifacts)	51
Figure A.10 – AI sub-component for image registration test object, Case A	52
Figure A.11 – POM sub-components for image registration test object, Case A	53
Figure A.12 – Cylinder test object (NEQ and CT value consistency) Case B.....	54
Figure A.13 – Object length test object, Cases A and B	55
Figure A.14 – Path length test object, Case A.....	56
Figure A.15 – SSP test object, Case B	57
Figure A.16 – Partition panel for component support, Cases A and B (drawing 1 of 4)	58
Figure A.17 – Partition panel for component support, Case A (drawing 2 of 4).....	59
Figure A.18 – Partition panel for component support, Case B (drawing 3 of 4).....	60
Figure A.19 – Partition panel for component support, Case B (drawing 4 of 4).....	61
Figure A.20 – Component support rods, Cases A and B.....	62
Figure A.21 – Assembly washers, Cases A and B.....	63
Figure A.22 – Sub-assembly for Case A cylinder test object.....	64
Figure A.23 – Sub-assembly for Case A image registration test object	65
Table 1 – List of test methods and indicators measured.....	16
Table 2 – NEQ procedure results	29
Table 3 – CT value uniformity results	32
Table 4 – Streak artifact procedure results	34
Table 5 – SSP procedure results.....	36
Table A.1 – Commercial foils required for fabrication of CT value uniformity and x-ray energy spectrum consistency test object (4.8)	41

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RADIATION PROTECTION INSTRUMENTATION –
MEASURING THE IMAGING PERFORMANCE OF X-RAY
COMPUTED TOMOGRAPHY (CT) SECURITY-SCREENING 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 62945 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

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

FDIS	Report on voting
45B/908/FDIS	45B/910/RVD

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document 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 document establishes standard test methods and test objects for measuring the imaging performance of x-ray computed tomography (CT) security-screening systems. The quality of data for automated analysis is the primary concern. This document does not address the system's ability to use its image data to automatically detect explosives or other threat materials, which is typically verified by an appropriate regulatory body.

Three annexes are included. Annex A (normative) provides mechanical drawings of the imaging test objects that compose the test article. A sample test report form is given in Annex B (informative). Annex C (informative) offers statistical guidance on multiple scans, summary statistics, and comparison of results. Finally, a bibliography is given (informative).

Currently in preview, click buy full version

RADIATION PROTECTION INSTRUMENTATION – MEASURING THE IMAGING PERFORMANCE OF X-RAY COMPUTED TOMOGRAPHY (CT) SECURITY-SCREENING SYSTEMS

1 Scope

This document provides test methods for the evaluation of image quality of computed tomography (CT) security-screening systems. The quality of data for automated analysis is the primary concern. This document does not address the system's ability to use this image data to automatically detect explosives or other threat materials, nor is it intended for vendor-to-vendor comparisons of threat-detection performance.

Security screening systems are generally used to scan parcels, including luggage, for the presence of illicit items such as explosives, drugs, or other contraband. Many of the screening systems currently used, particularly in transportation security applications, are based on CT imaging technology. Generally, as the parcel is transported through the system, the system collects a CT image of the parcel. These data are then subjected to automated analysis to determine whether a threat may be present or the parcel is considered clear. If the automated analysis determines a threat may be present, the image is often presented to a system operator who can override the automated decision, clear the parcel, or referring it for further processing such as opening it and manually searching for threats.

Historically, government regulators have established evaluation procedures to determine whether a system's automated detection performance is adequate for use in applications within their borders. Typically, a vendor submits a copy of their product, including their software to the regulator's facility. The regulator tests a wide variety of parcels with threats inside through the system as well as parcels without threats that represent the typical stream of commerce. Detection and false alarm rates are determined and compared against performance criteria. If the criteria are met, the system is approved for use. This testing ensures that the system is capable of meeting the required criteria, but how does one ensure that all copies of the system meet the criteria? Normal manufacturing variability, quality control issues, or aging of the equipment may degrade performance versus what was observed on the article tested by the regulator. Replicating the original test on each machine in question is impractical. Transporting the regulator's threat set to a factory site or to locations where the machines are in use presents significant security and in some cases safety concerns. This document seeks to address this issue by specifying a suite of test methods that can be carried out on site without need for hazardous materials.

The performance testing carried out by the regulators essentially evaluates the combination of the system's ability to produce an image of the parcel along with its automatic analysis of that image data to reach a decision of threat or clear. The second part of this sequence, the analysis, is implemented through software. Regulators generally require that this software be designed so as to not evolve through use. The software used at all locations in the field must perform the same as the software did at the time of evaluation by the regulator. Configuration management of such software is a well-known and straightforward art. Therefore, the real opportunity for performance variation comes from the imaging system that provides the data to the analysis software. If one can quantitatively validate that the quality of the image produced by the system in question is statistically equivalent to the image produced by the article evaluated by the regulator, one can be highly confident that the performance of the system in question is the same as what was approved by the regulator.

Purchasers of CT systems for security screening applications are generally not CT experts. Inconsistencies in methods for measuring seemingly standard image quality values (resolution, signal-to-noise, etc.) can confuse the potential user of such CT systems. Other standards exist for testing aspects of CT image quality, particularly in the medical field. This document specifies a set of methods to apply in assessing CT image quality geared towards security