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

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

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

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ELECTROTECHNICAL
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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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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 or anomalies 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.

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

[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).

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

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, power supply, source voltage and current, and filtration, and which are the same as the machine settings for radiation safety testing (measuring the effective dose). Since effective dose and image quality are interrelated, the system shall comply with the effective dose requirements in IEC 62463. General-use systems shall deliver an effective dose of less than 0,25 µSv per screening. Limited-use systems shall deliver a dose of less than 10 µSv per screening. See IEC 62463 for more details on the system classes and effective dose estimation methods.

These machine settings and the effective dose shall be included in the test report (for an example, see Annex B) to facilitate the evaluation 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.

Each test should be repeated 3 times.

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 perpendicular with the floor and at the optimum operating distance as specified by the manufacturer and,

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 floor of the scanner. 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.

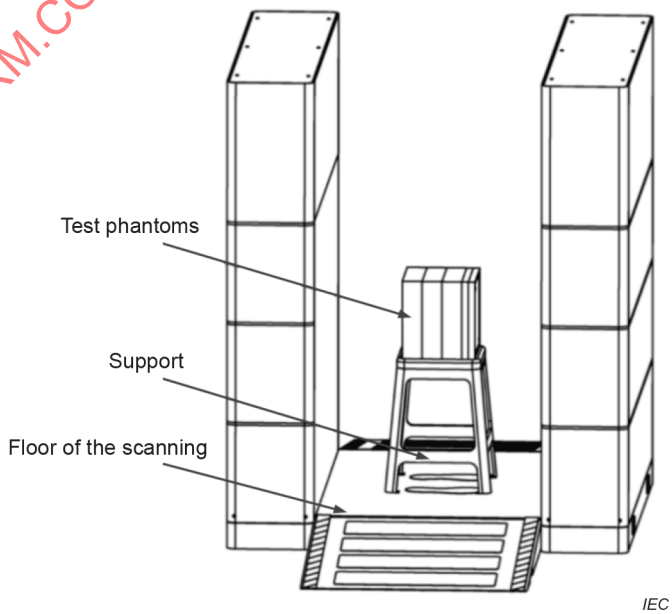


Figure 1 – Generic illustration of the testing configuration showing a HDPE body phantom with a test object on one end supported 1 m off the ground

Additionally, off-centre tests may 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 document 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, an HDPE cube, 300 mm on each side, is used to simulate the human body.

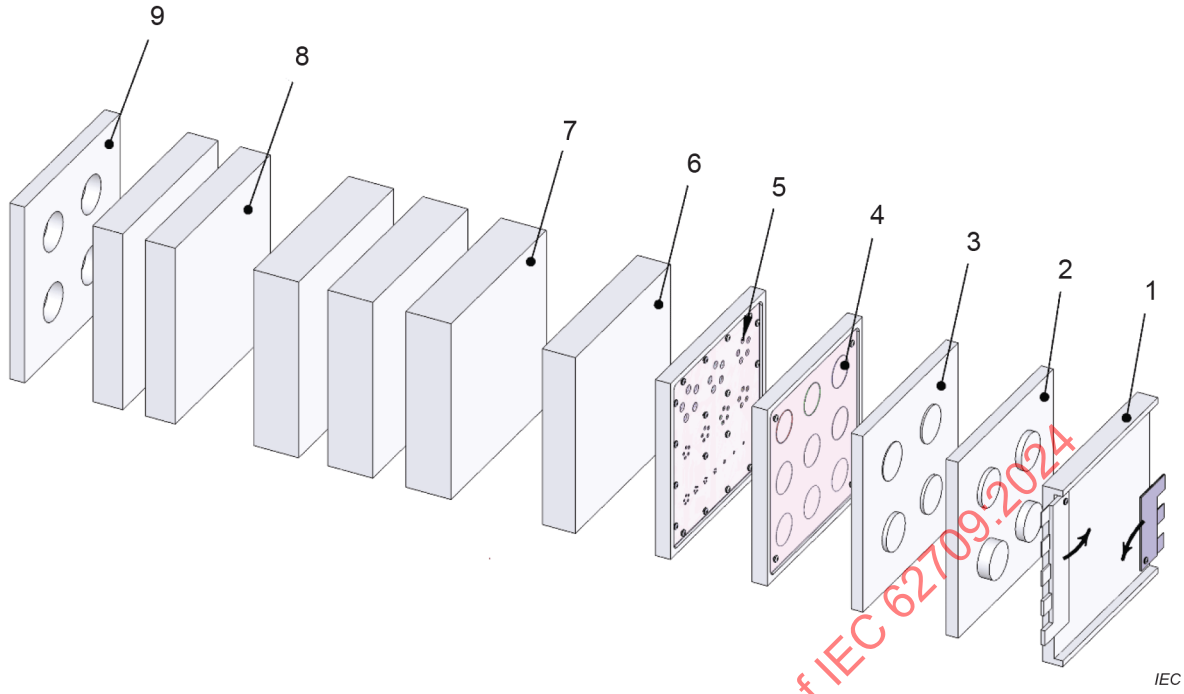
For general-use transmission systems, it is acceptable to use a reduced body phantom with dimensions of 300 mm wide × 300 mm high × 230 mm deep, so that the overall HDPE depth of the body phantom and test object assembly shall be 250 mm.

For the penetration test for limited-use systems, the overall depth shall be expandable from 300 mm to 400 mm by attaching additional 50 mm thick HDPE slabs.

For the penetration test of general-use systems, the overall depth shall be expandable from 250 mm to 300 mm by attaching additional 25 mm thick HDPE slabs.

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	additional phantom, 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 Pentalith 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 pentalith 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 683-17:2023, grade designation 100Cr6 or equivalent (e.g. AISI/SAE 52100 in ASTM A295/A295M-14:2020, 1.3505 in EN 10027-2; SUJ2 in JIS G4805) 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.

The pentalith assembly is attached to the body phantom to form a solid HDPE block that is 300 mm on a side. Mechanical drawings of the pentalith resolution test object are given in Figure A.1, Figure A.13, Figure A.14, Figure A.15 and Figure A.16.

4.4.3 Procedure

A test object meeting the description in 4.4.2 and a body phantom as described in 4.3 shall be used for this test.

The test object shall be mounted on the body phantom and positioned at the reference location (see 4.2) as follows. For backscatter and/or forward scatter systems, the surface of the body phantom containing the test object shall be the surface closest to the radiation source. For transmission systems, either the surface containing the test object or the opposite surface shall face the radiation source (the orientation of the body phantom shall be recorded in the test report).

The test object shall be scanned as in normal use as defined in 4.1.

The procedure may be repeated at other desired testing locations.

4.4.4 Evaluation and record

Find the smallest pentagon for which all five spheres are visible as completely separate objects. Software image adjustments available to the operator may be used to obtain optimum contrast and brightness. The settings for any adjustments shall be recorded in the test report. For example, if contrast and brightness adjustments are available to the operator, the following is an acceptable procedure for testing separation and for achieving reproducible measurements: turn the contrast all the way up, adjust the brightness to see if five separate islands can be formed. See Annex C for further information related to objectively scoring this test.

Record the smallest sphere diameter meeting the above analysis.

The reported results shall be the sphere diameter of the smallest pentalith that was detected in at least two thirds of the images.

4.5 Wire detection test

4.5.1 Purpose

The purpose of this test is to determine the minimum diameter of copper wire that can be detected.

4.5.2 Test object description

The wire detection test object consists of nine copper wires, each forming a circle with a nominal diameter of 50 mm. The wires are attached on the surface of a HDPE block having dimensions of 300 mm × 300 mm × 25 mm. (Alternatively, the wires may be mounted on a 6,4 mm thick sheet using an additional 19 mm HDPE spacer). A 1,5 mm thick sheet of HDPE is placed over the wires to simulate a layer of thick clothing.

The following wire sizes are included on the test object (see Table 1).

Table 1 – Wire sizes for the wire detection test

Nominal diameter mm
0,812
0,644
0,511
0,405
0,321
0,255
0,202
0,160
0,127

Mechanical drawings of the wire detection test object are given in Figure A.1, Figure A.7, Figure A.11 and Figure A.9.

4.5.3 Procedure

A test object meeting the description in 4.5.2 and body phantom as described in 4.3 shall be used for this test.

The test object shall be mounted on the body phantom so that the surface on which the wires are placed faces away from the HDPE cube. The body phantom and test object shall be positioned at the reference location (see 4.2) as follows. For backscatter and/or forward systems the surface of the body phantom containing the test object shall be the surface closest to the radiation source. For transmission systems, either the surface containing the test object or the opposite surface shall face the radiation source (the orientation of the body phantom shall be recorded in the test report).

The procedure may be repeated at other desired testing locations.

4.5.4 Evaluation and record

Identify and record the smallest wire gauge for which a contiguous length of at least half the circle circumference is visible. Image adjustments available to the operator may be used to obtain optimum contrast and brightness. The settings for any adjustments shall be recorded in the test report.

The reported results shall be the diameter of the smallest wire gauge that was detected in at least two thirds of the images.

4.6 Materials detection on body test

4.6.1 General

This test is intended to measure the ability to detect objects on the body that are of a density similar to that of the body. Depending on the properties of the scanning system, this test may serve as either a contrast sensitivity test or edge detection test.

4.6.2 Purpose

The purpose of this test is to measure the ability to observe step changes in thickness of flat organic material superimposed on the flat body phantom.

4.6.3 Test object description

The test object consists of HDPE discs placed over the body phantom. The discs are 60 mm in diameter and have thicknesses of 1,5 mm, 3 mm, 5 mm, 7 mm, 10 mm, 14 mm, and 20 mm. The discs are attached on the surface of a 300 mm × 300 mm × 25 mm HDPE sheet and are spaced at least 60 mm apart. (Alternatively, the discs may be mounted on a 6,4 mm thick sheet using an additional 19 mm HDPE spacer). In order to adequately space the discs, the seven thicknesses are distributed on two HDPE sheets. The 7 mm thickness is repeated on each set for reference. Mechanical drawings of the materials detection on body test object are given in Figure A.1, Figure A.8 and Figure A.9.

4.6.4 Procedure

A test object meeting the description in 4.6.3 and body phantom as described in 4.3 shall be used for this test.

The test object shall be mounted on the body phantom and positioned at the reference location (see 4.2) as follows. For backscatter and/or forward-scatter systems the surface of the body phantom containing the test object shall be the surface closest to the radiation source. For transmission systems, either the surface containing the test object or the opposite surface shall face the radiation source (the orientation of the body phantom shall be recorded in the test report).

Each set of discs shall be scanned using the normal scanning procedure as defined in 4.1.

The procedure may be repeated at other desired testing locations.

4.6.5 Evaluation and record

Identify and record the smallest disc thickness that is observable. Observable means that at least one half of the circumference can be discerned. Image adjustments that are available to the operator may be used to obtain optimum contrast and brightness. The settings for any adjustments shall be recorded in the test report.

The reported results shall be the thickness of the smallest disc that was detected in at least two thirds of the images.

4.7 Materials detection in air test

4.7.1 General

This test is intended to measure the ability to detect objects hidden in clothing on the sides of the body, when the image of the objects is not superimposed on the image of the body.

4.7.2 Purpose

The purpose of this test is to measure the ability to observe objects of different materials and thicknesses in air.

4.7.3 Test object description

The test object consists of two "combs" having square teeth of varying thickness. The teeth are 25 mm wide by 25 mm long and are separated by 25 mm. The first comb is made of HDPE and includes teeth thicknesses of 1,2 mm, 2,0 mm, 3,0 mm, 5,0 mm, and 7,0 mm. The second comb is made of stainless steel, SST-304 alloy (an equivalent material may be utilized, provided it is no more radio-opaque under comparable penetrating radiation energy conditions), and includes teeth thicknesses of 0,8 mm, 1,6 mm, and 3,2 mm. The combs are placed on a 300 mm × 300 mm × 25 mm HDPE sheet for mounting on the body phantom. (Alternatively, the combs may be mounted on a 6,4 mm thick sheet using an additional 19 mm HDPE spacer). The supporting sheet may also contain another test object. The combs are placed so that the teeth extend beyond the upright edges of the body phantom and do not overlap any part of the body phantom in the image. Mechanical drawings of the materials detection in air test object are given in Figure A.1 through Figure A.7.

4.7.4 Procedure

A test object meeting the description in 4.7.3 and a body phantom as described in 4.3 shall be used for this test.

The test object shall be mounted on the body phantom and positioned at the reference location (see 4.2) as follows. For backscatter and/or forward-scatter systems, the surface of the body phantom containing the test object shall be the surface closest to the radiation source. For transmission systems, either the surface containing the test object or the opposite surface shall face the radiation source (the orientation of the body phantom shall be recorded in the test report).

The test object shall be scanned using the normal scanning procedure as defined in 4.1.

The procedure may be repeated at other desired testing locations.

4.7.5 Evaluation and record

Identify and record the thinnest tooth observable for each material. Observable means that at least one half of the 25 mm × 25 mm tooth area can be discerned. Image adjustments that are available to the operator may be used to obtain optimum contrast and brightness. The settings for any adjustments shall be recorded in the test report.

The reported results shall be the thicknesses of the thinnest tooth that was detected in at least two thirds of the images.

4.8 Penetration test

4.8.1 General

This test applies only to transmission systems or other modalities if the intent is to image inside the body.

4.8.2 Purpose

The purpose of this test is to measure any degradation of pentalith resolution and wire detection with increased body size.

4.8.3 Test object description

The test object consists of two 300 mm × 300 mm × 50 mm slabs of HDPE to be added to the body phantom on the opposite side as the other test objects. Mechanical drawings of the penetration test object are given in Figure A.1 and Figure A.19.

4.8.4 Procedure

Repeat the pentalith resolution and wire detection tests of 4.4 and 4.5 with a 50 mm thickness of HDPE added to the body phantom (on the side opposite the resolution or wire detection test object) and again with a total of 100 mm of HDPE added.

4.8.5 Evaluation and record

Evaluate and record the results as in 4.4.4 and 4.5.4.

5 Minimum acceptable imaging performance

The security screening systems covered by the scope of this document shall meet the minimum imaging performance requirements shown in Table 2. These minimum requirements apply to the testing performed at the reference location, as described in 4.2, according to the methods in 4.4 through 4.8. The machine settings and the effective dose requirements during the test are described in 4.1. Different minimum performance requirements are given for systems employing the three fields of view,viz., partial body (3.1.12), whole body (3.1.29), and wide (3.1.30).

For general-use transmission systems the test results are all report only (i.e. the minimum acceptable imaging performance requirements do not apply).

Table 2 – Minimum acceptable imaging performance at the reference location

	Image quality test	Whole body field of view	Partial body field of view	Wide field of view	Relevant subclause
1	Pentalith resolution: smallest sphere diameter resolved	6 mm	2,5 mm	14 mm	4.4
2	Wire detection: smallest wire detected	0,511 mm	0,321 mm	RO[c]	4.5
3	Materials detection on body: thinnest disc discerned	5 mm	5 mm	RO	4.6
4	Materials detection in air:				4.7
	smallest plastic thickness discerned	3 mm	2 mm	RO	
	smallest metal thickness discerned	1,6 mm	0,8 mm	RO	
5	Penetration test				4.8
	a) through 350 mm HDPE[a]:				
	smallest sphere diameter resolved	RO	RO	optional	
	smallest wire detected	RO	RO	optional	
	b) through 400 mm HDPE[b]:				
	smallest sphere diameter resolved	RO	RO	optional	
	smallest wire detected	RO	RO	optional	

[a] Though 275 mm HDPE for transmission general-use systems.

[b] Though 300 mm HDPE for transmission general-use systems.

[c] RO: Report only; there is no minimum requirement.

6 Environmental requirements

To ensure uniformity of test results, all the image quality tests in this document summarized in first column of Table 2 shall be performed under the standard test conditions specified in Table 3.

Table 3 – Standard test conditions

Influence quantities	Standard test conditions (unless otherwise indicated by the manufacturer)
Warm-up time	>15 min
Ambient temperature	22 °C ± 5 °C
Relative humidity	30 % to 75 %
Atmospheric pressure	86 kPa to 106 kPa
Power supply voltage	Rated power supply voltage ±10 %
Power supply frequency	Nominal frequency ±1 %
Power supply waveform	Sinusoidal with total harmonic distortion lower than 5 %
Gamma radiation background	Less than air kerma rate of 0,25 μGy·h^{-1}
Electromagnetic field of external origin	Less than the lowest value that causes interference
Magnetic induction of external origin	Less than twice the value of the induction due to earth's magnetic field
Equipment controls	Set up for normal operation

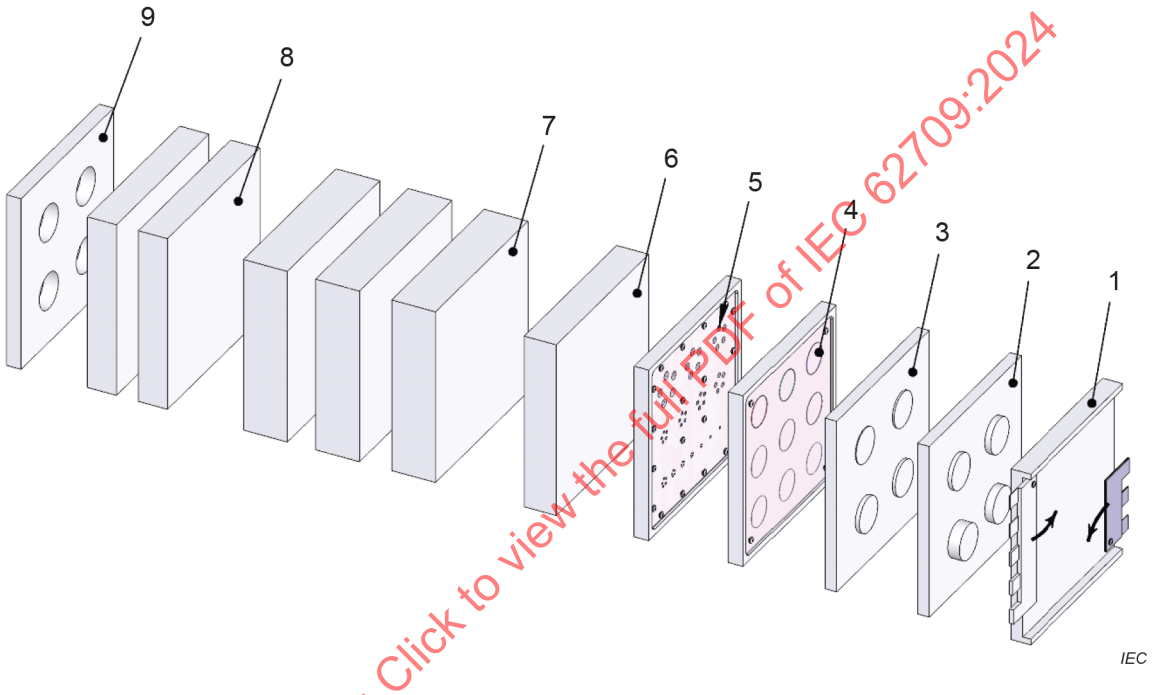
If the system is intended for operation in environmental conditions significantly outside the ranges specified in Table 3, additional testing should be done to demonstrate that the imaging performance reported for standard test conditions remains unchanged at the low temperature/low-humidity limit and at the high-temperature/high-humidity limit of the intended range.

The value of ambient air temperature, relative humidity, and atmospheric pressure at the time of the test shall be recorded (see, e.g., Annex B). The environmental conditions stated in Table 3 take priority over other environmental conditions stated in the referenced standards.

Annex A
(normative)

Mechanical drawings of the test objects

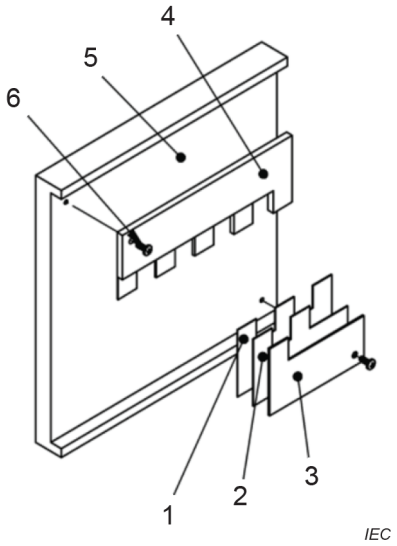
This Annex contains a complete set of mechanical drawings for the test objects specified in this document and is normative in the sense that it reflects the requirements of this document See Figure A.1 through Figure A.20. Other implementations of test objects that deviate from these drawings, but continue to conform to the dimensional and material specifications of this document, are permitted. Unless otherwise specified, dimensions are in mm. Tolerances: angular: ±0,5°; X/.x±0,3 mm; 0, xx±0,15 mm.



Key

1	material detection in air	Figure A.2 through Figure A.7	Quantity 1
2	material detection on body 1	Figure A.8	Quantity 1
3	material detection on body 2	Figure A.9	Quantity 1
4	wire detection test	Figure A.10 through Figure A.12	Quantity 1
5	pentalith resolution	Figure A.13 through Figure A.16	Quantity 1
6	body phantom,55 mm thick	Figure A.17	Quantity 1
7	body phantom,75 mm thick	Figure A.18	Quantity 3
8	penetration test,50 mm thick	Figure A.19	Quantity 2
9	storing spacer	Figure A.20	Quantity 1

Figure A.1 – Components of the test phantom



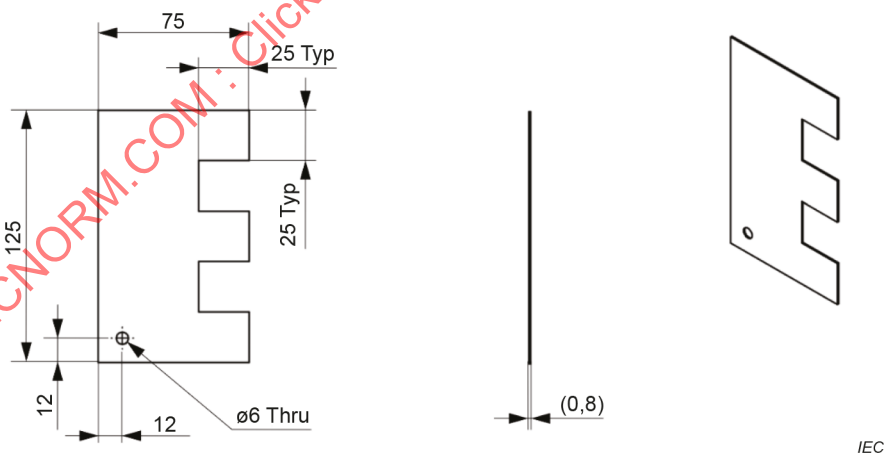
Key

1	metal comb, three teeth	Quantity 1
2	metal comb, two teeth	Quantity 1
3	metal comb, one tooth	Quantity 1
4	plastic comb, five teeth	Quantity 1
5	combs mounting sheet	Quantity 1
6	Phillips head screws, M5×12,18-8 SST	Quantity 2

NOTE 1 See 4.7.2 for detailed materials specifications.

NOTE 2 Figure A.3 through Figure A.7 show additional details.

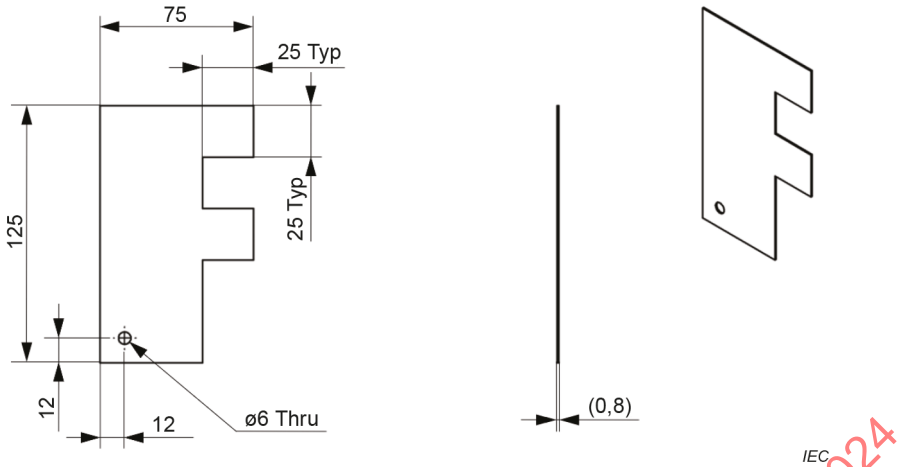
Figure A.2 – Material detection in air phantom



NOTE 1 This is fabricated from stainless steel (SST-304 alloy or equivalent).

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

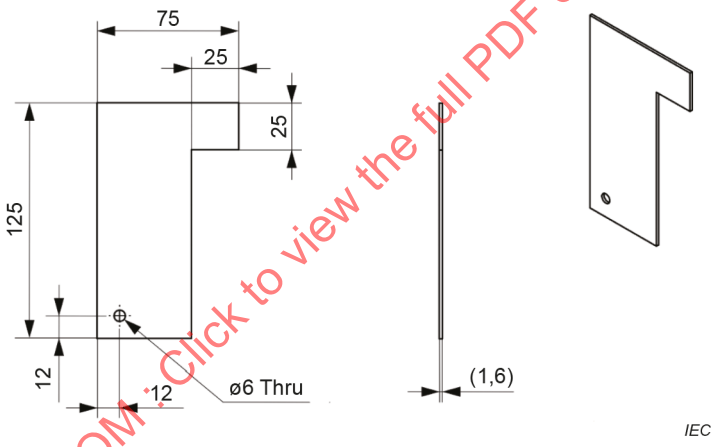
Figure A.3 – Subassembly of the material detection in air phantom (Figure A.2), metal comb, three teeth



NOTE 1 This is fabricated from stainless steel (SST-304 alloy or equivalent).

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

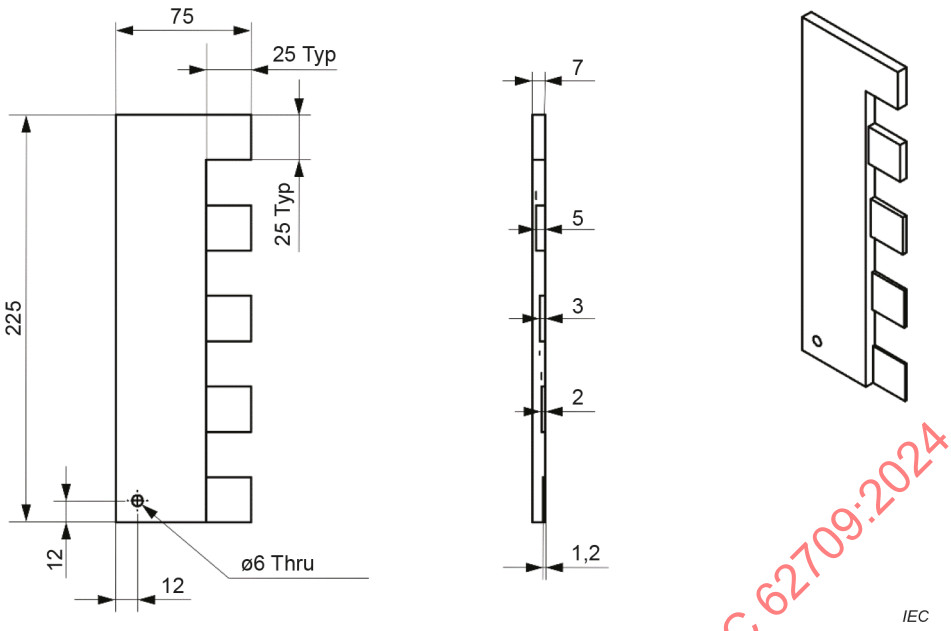
Figure A.4 – Subassembly of the material detection in air phantom (Figure A.2), metal comb, two teeth



NOTE 1 This is fabricated from stainless steel (SST-304 alloy or equivalent).

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

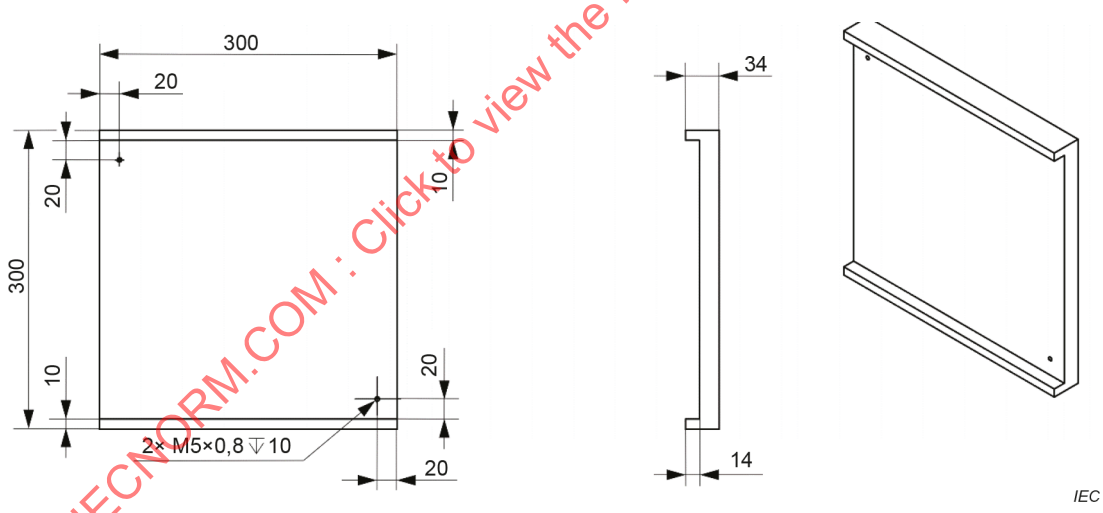
Figure A.5 – Subassembly of the material detection in air phantom (Figure A.2), metal comb, one tooth



NOTE 1 This is fabricated from stainless steel (SST-304 alloy or equivalent).

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

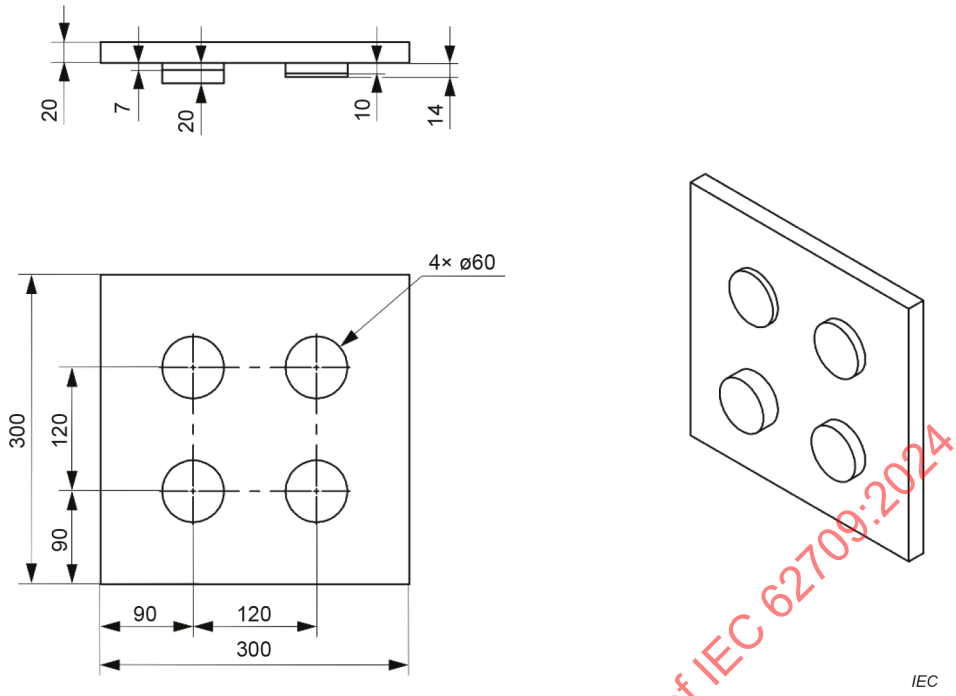
Figure A.6 – Subassembly of the material detection in air phantom (Figure A.2), plastic comb



NOTE 1 This is fabricated from HDPE plastic .

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

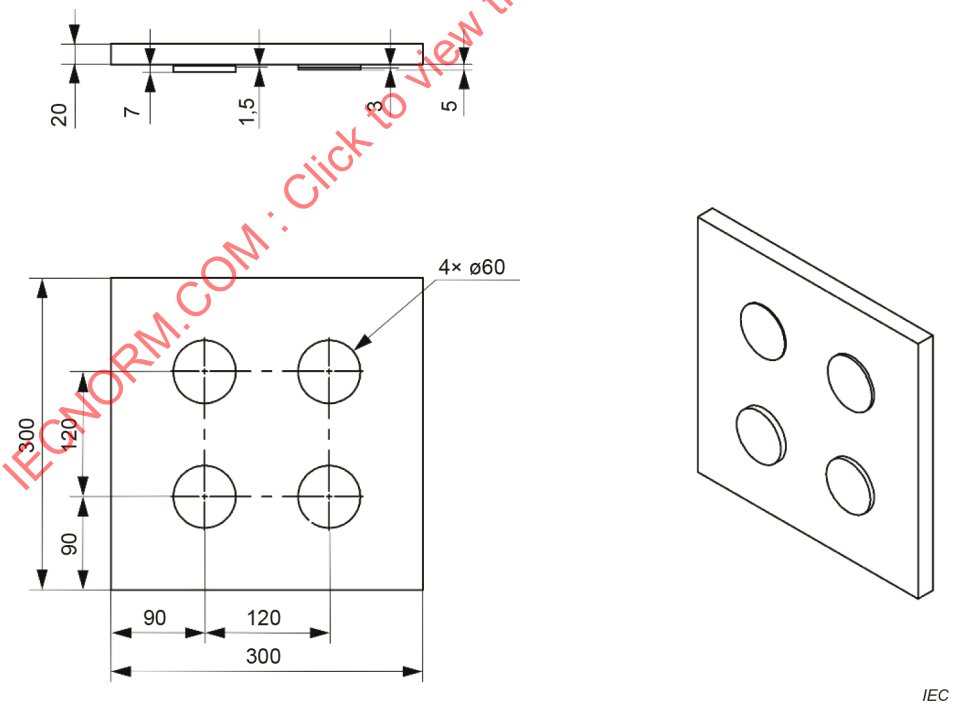
Figure A.7 – Subassembly of the material detection in air phantom (Figure A.2), mounting sheet



NOTE 1 This is fabricated from HDPE.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

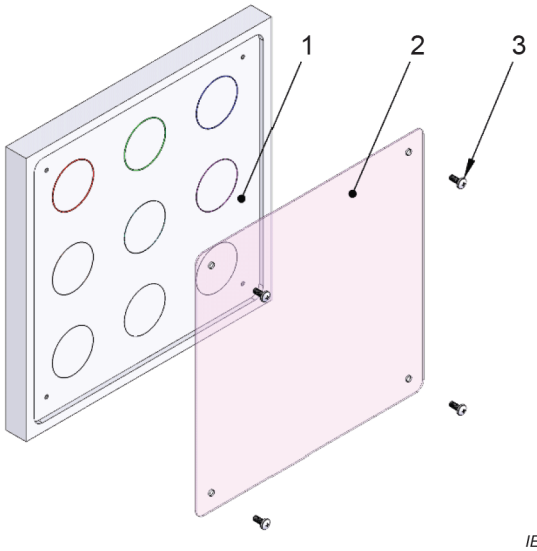
Figure A.8 – Material detection on body 1



NOTE 1 This is fabricated from HDPE.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3 mm; 0, xx ±0,15 mm.

Figure A.9 – Material detection on body 2



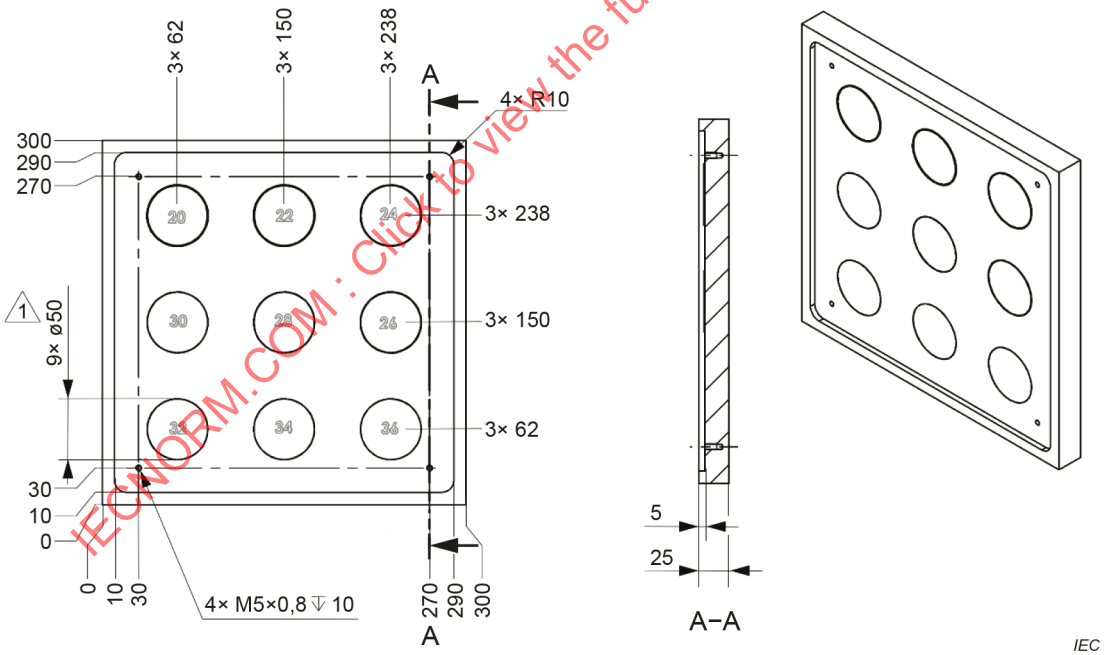
Key

1 base, see Figure A.11

2 cover, see Figure A.12

3 screws

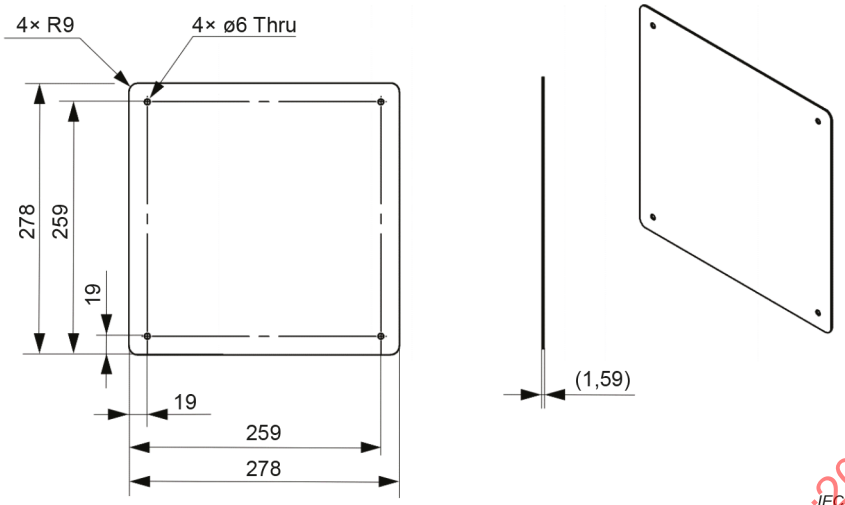
Figure A.10 – Wire detection phantom



NOTE 1 The base is fabricated from HDPE plastic. The thicknesses of the copper wires are given in Table 1.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0, xx ±0,15.

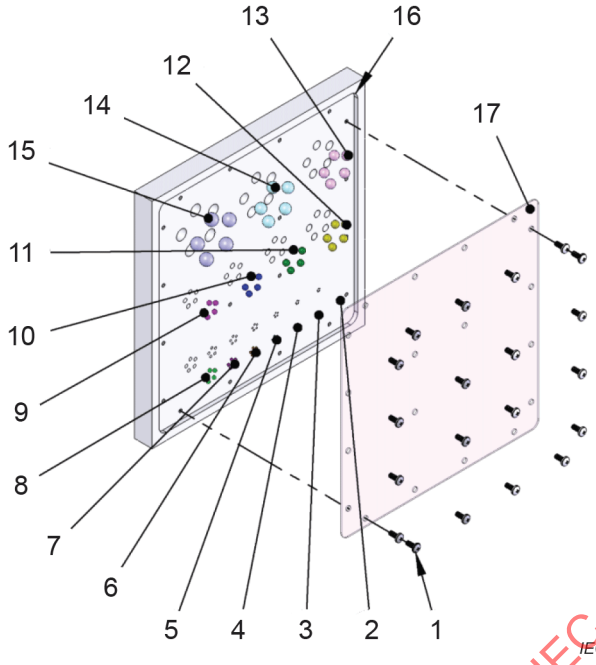
Figure A.11 – Subassembly of the wire detection phantom (Figure A.10), mounting base



NOTE 1 This part is fabricated from transparent polycarbonate plastic.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0, xx ±0,15.

Figure A.12 – Subassembly of the wire detection phantom (Figure A.10), cover

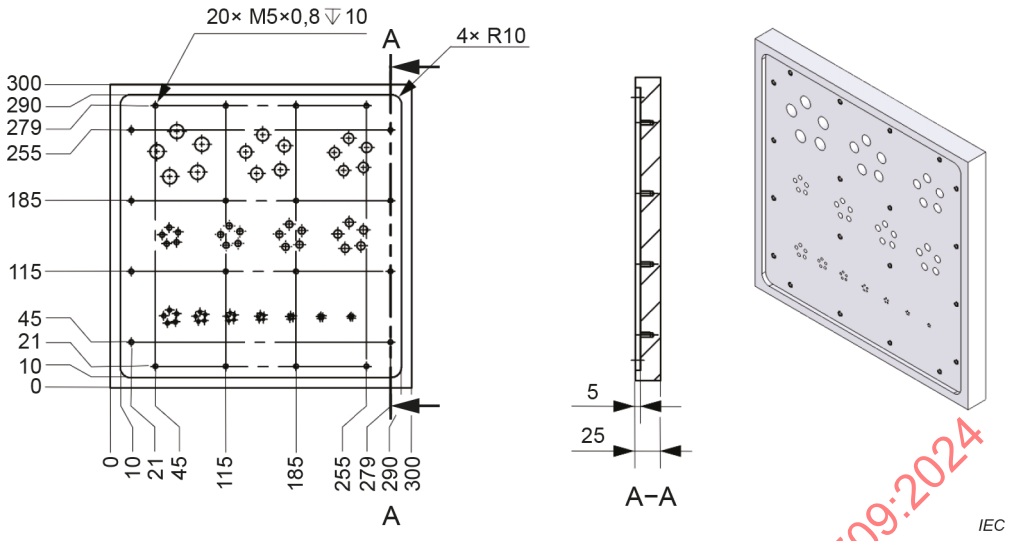


Key

1 Phillips screws, M5×12,nylon,quantity 20
2 steel ball bearing,1,0 mm diameter, quantity 5
3 steel ball bearing,1,2 mm diameter, quantity 5
4 steel ball bearing,1,5 mm diameter, quantity 5
5 steel ball bearing, 2,0 mm diameter, quantity 5
6 steel ball bearing, 2,5 mm diameter, quantity 5
7 steel ball bearing, 3,0 mm diameter, quantity 5
8 steel ball bearing, 4,0 mm diameter, quantity 5
9 steel ball bearing, 5,0 mm diameter, quantity 5
10 steel ball bearing, 6,0 mm diameter, quantity 5
11 steel ball bearing, 7,0 mm diameter, quantity 5
12 steel ball bearing, 8,0 mm diameter, quantity 5
13 steel ball bearing,10,0 mm diameter, quantity 5
14 steel ball bearing,12,0 mm diameter, quantity 5
15 steel ball bearing,14,0 mm diameter, quantity 5
16 base, resolution test, quantity 1
17 cover, resolution test, quantity 1

NOTE Figure A.14 through Figure A.16 show additional details.

Figure A.13 – Pentalith resolution phantom



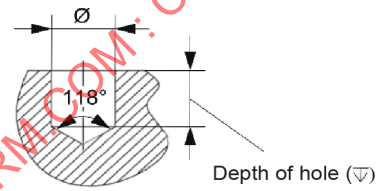
NOTE 1 This part is fabricated from HDPE plastic.

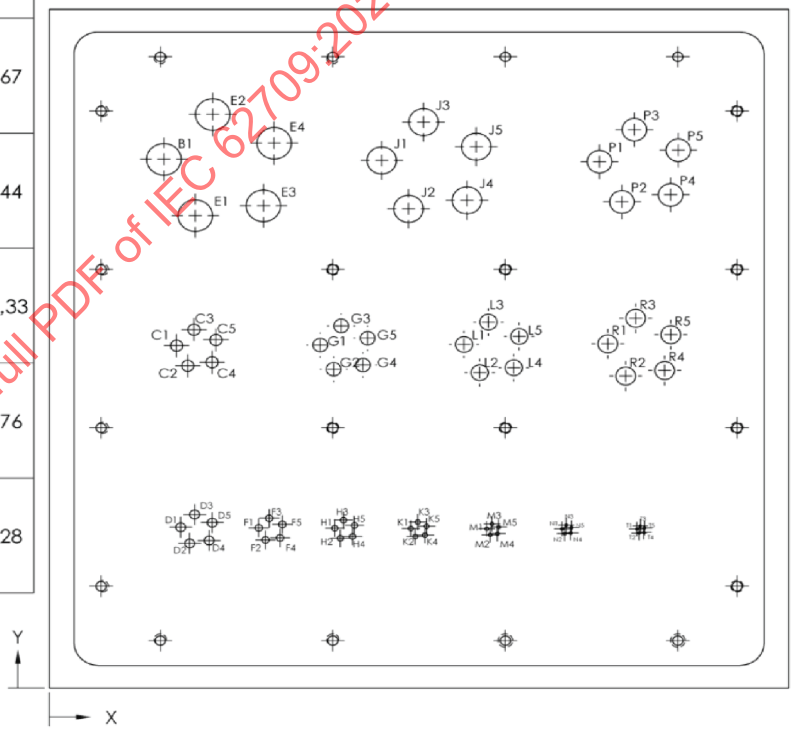
NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3;0, xx ±0,15.

Figure A.14 – Subassembly of the pentalith resolution phantom (Figure A.13), mounting base

Hole table			
TAG	X LOC	Y LOC	Size
B1	46,47	233,73	Ø14,0 DRILL ↧ 11,46
E1	59,19	208,78	
E2	66,27	253,53	
E3	86,84	213,16	
E4	91,22	240,81	
C1	51,60	151,33	Ø5,0 DRILL ↧ 4,41
C2	56,14	142,42	
C3	58,67	158,40	
C4	66,02	143,99	
C5	67,58	153,86	
D1	53,28	71,06	Ø4,0 DRILL ↧ 3,63
D2	56,91	63,94	
D3	58,94	76,72	
D4	64,81	65,19	
D5	66,06	73,09	
F1	84,96	70,80	Ø3,0 DRILL ↧ 2,85
F2	87,68	65,45	
F3	89,20	75,04	
F4	93,61	66,39	
F5	94,55	72,32	
G1	109,92	151,60	Ø6,0 DRILL ↧ 5,20
G2	115,37	140,90	
G3	118,40	160,08	
G4	127,22	142,78	
G5	129,10	154,63	
H1	115,80	70,67	Ø2,5 DRILL ↧ 2,46
H2	118,07	66,21	
H3	119,33	74,20	
H4	123,01	66,99	
H5	123,79	71,93	
J1	134,84	233,19	Ø12,0 DRILL ↧ 9,89
J2	145,73	211,81	
J3	151,81	250,16	
J4	169,44	215,56	
J5	173,19	239,27	
K1	146,64	70,53	Ø2,0 DRILL ↧ 2,07
K2	148,46	66,97	
K3	149,47	73,36	
K4	152,41	67,59	
K5	153,03	71,54	

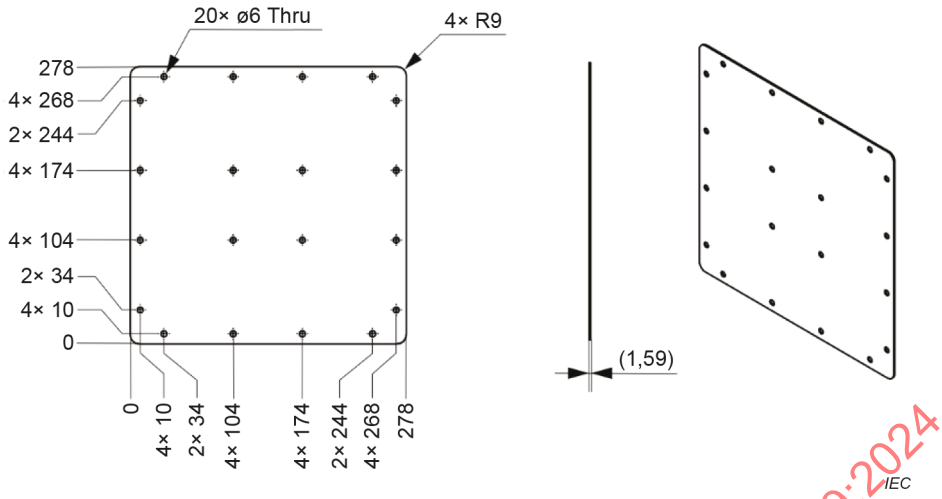
Hole table			
TAG	X LOC	Y LOC	Size
L1	168,24	151,86	Ø7,0 DRILL ↧ 5,98
L2	174,59	139,39	
L3	178,14	161,76	
L4	188,42	141,58	
L5	190,61	155,41	
M1	177,48	70,40	Ø1,5 DRILL ↧ 1,67
M2	178,84	67,73	
M3	179,60	72,52	
M4	181,80	68,20	
M5	182,27	71,16	
N1	207,98	70,32	Ø1,2 DRILL ↧ 1,44
N2	209,07	68,18	
N3	209,68	72,02	
N4	211,44	68,56	
N5	211,82	70,93	
P1	223,20	232,66	Ø10,0 DRILL ↧ 8,33
P2	232,28	214,84	
P3	237,34	246,80	
P4	252,03	217,97	
P5	255,16	237,72	
R1	226,56	152,13	Ø8,0 DRILL ↧ 6,76
R2	233,82	137,87	
R3	237,87	163,44	
R4	249,62	140,38	
R5	252,13	156,18	
T1	238,32	70,27	Ø1,0 DRILL ↧ 1,28
T2	239,23	68,48	
T3	239,73	71,68	
T4	241,20	68,80	
T5	241,52	70,77	





NOTE All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0,xx ±0,15

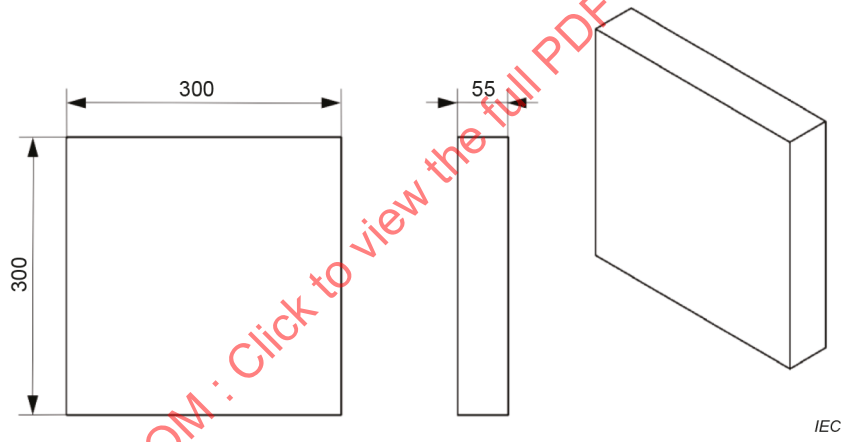
Figure A.15 – Subassembly of the pentalith resolution phantom (Figure A.13); hole placement in mounting base



NOTE 1 This part is fabricated from transparent polycarbonate plastic.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0,xx ±0,15.

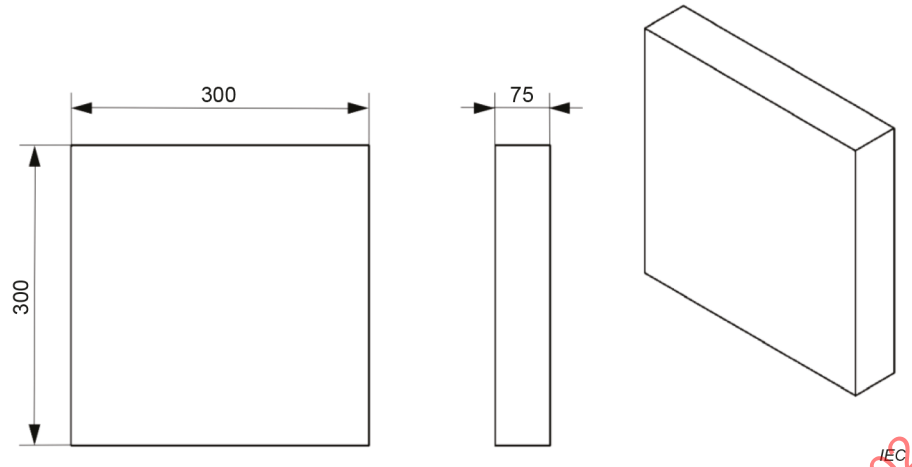
Figure A.16 – Subassembly of the pentalith resolution phantom (Figure A.13), cover



NOTE 1 This part is fabricated from HDPE plastic.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0,xx ±0,15.

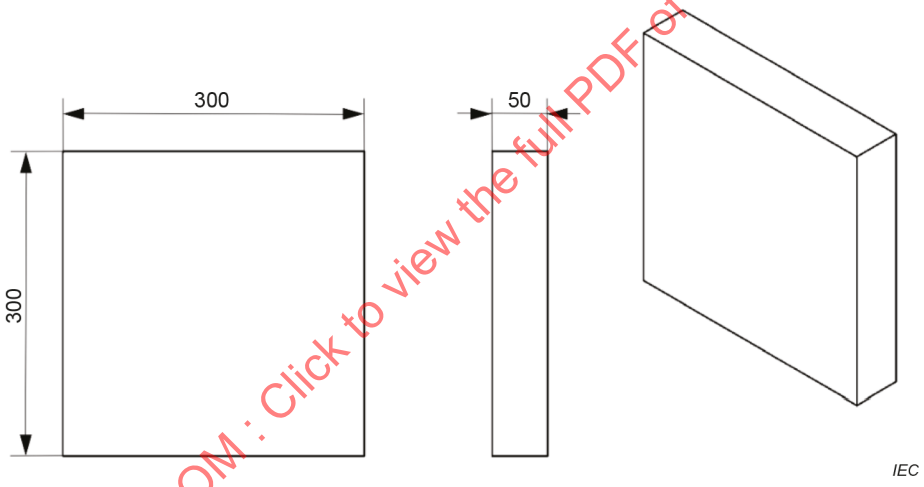
Figure A.17 – Body phantom, 55 mm thick



NOTE 1 This part is fabricated from HDPE plastic.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0,xx ±0,15.

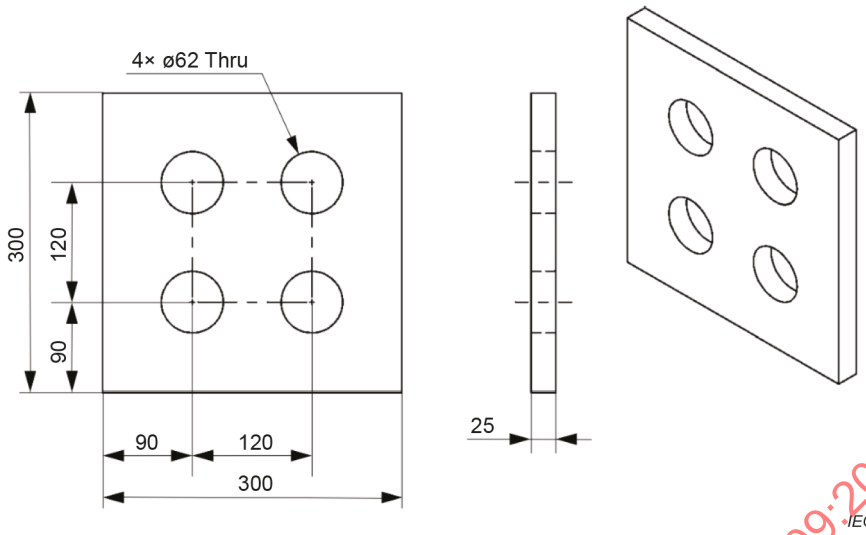
Figure A.18 – Body phantom, 75 mm thick



NOTE 1 This part is fabricated from HDPE plastic.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0,xx ±0,15.

Figure A.19 – Body phantom, 50 mm thick



NOTE 1 This part is fabricated from HDPE plastic.

NOTE 2 All dimensions are in mm. Tolerances: angular: ±0,5°; X/.x ±0,3; 0,xx ±0,15

Figure A.20 – Storing space

Annex B
(informative)

Example of reporting form

The following pages contain a sample form for recording the results of the imaging test.

IEC 62709 body scanner imaging test report

Doc. Ref.#:_____,Page 1 of 2

Tester(s):	Place:	Date/Time:
System manufacturer:	Model/Type:	Serial#:
Class of system:	☐Transmission ☐ Backscatter	☐ General-use ☐ Limited-use
Ambient temperature:	Relative humidity:	Barometric pressure:
Body phantom ID No.:		
Test objects ID Nos.:		
Machine settings (include all the operator control settings necessary to reproduce this test; for example kV, mA, scanning speed, filtration, mode, software version): Effective dose:		
Other test conditions:		
Test object placement		
Is the test object at the reference location (RL)? ☐Yes ☐No For transmission systems: test object facing ☐source ☐away from source		
Distance from beam-exit surface:		
If not RL: Lateral position_____☐left of RL ☐right of RL Height_____		
Transmission systems only: test objects placed on side of phantom ☐nearest ☐furthest from the radiation source.		

Other objects in field of view	**Distance and location**

IEC 62709 body scanner imaging test report

Doc. Ref.#:_____,Page 2 of 2

Test		Image enhancement features and settings used				
1.Pentalith resolution						
2.Wire detection						
3.Materials detection on body						
4.Materials detection in air						
5.Penetration						
Type	**Image quality test**	**Minimum requirement**				**Pass (√)**
		☐ Whole body	**☐ Partial body**	**☐ Wide view**	**Test results**	
1	Pentalith resolution: smallest sphere diameter resolved	6 mm	2,5 mm	14 mm		
2	Wire detection: smallest wire detected	0.511 mm	0.321 mm	RO[c]		
3	Materials detection on body: thinnest disc discerned	5 mm	5 mm	RO		
4	Materials detection in air:					
	smallest plastic thickness discerned	3 mm	2 mm	RO		
	smallest metal thickness discerned	1,6 mm	0,8 mm	RO		
5	Penetration test (applies to transmission systems only):					
	through 350 mm HDPE[a]	RO	RO	Optional		
	smallest sphere diameter resolved smallest wire detected	RO	RO	Optional		
	through 400 mm HDPE[b]:					
	smallest sphere diameter resolved	RO	RO	Optional		
	smallest wire detected	RO	RO	Optional		

List of attachments:

Notes:

The image evaluation tests above were conducted in accordance with IEC 62709

_____Signature

[a] Though 275 mm HDPE for transmission general-use systems.

[b] Though 300 mm HDPE for transmission general-use systems.

[c] RO: Report only.