BSI Standards Publication

Radiation protection instrumentation — Cargo/vehicle radiographic inspection system

National foreword

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RADIATION PROTECTION INSTRUMENTATION – CARGO/VEHICLE RADIOGRAPHIC INSPECTION SYSTEM

FOREWORD

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International Standard IEC 62523 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/638/FDIS	45B/652/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 amendment and the base 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- withdrawn,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.

RADIATION PROTECTION INSTRUMENTATION – CARGO/VEHICLE RADIOGRAPHIC INSPECTION SYSTEM

1 Scope and object

This International Standard applies to radiographic inspection systems with photon radiation energy of at least 500 keV for inspection of cargo, vehicles and cargo containers.

Such inspection systems generally consist of radiation source(s), detectors, control system, image processing system, radiation safety system and other auxiliary devices/facilities.

The object of this standard is to define the tests and the relevant testing methods for determining the performance characteristics of the radiographic inspection systems.

This standard is not applicable to those cargo/vehicle inspection systems using neutron source radiography, computed tomography or backscatter technology.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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 60204-1:2005, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61010-1:2001, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

ISO 4948-1, *Steels – Classification – Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

ISO 9978:1992, *Radiation protection – Sealed radioactive sources – Leakage test methods*

IAEA Safety Guide No.RS-G-1.10, *Safety of Radiation Generator and Sealed Radioactive Sources*

IAEA Safety Guide No.TS-R-1, *Regulations for the Safe Transport of Radioactive Material*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply, as well as those given in IEC 60050-393 and IEC 60050-394.

3.1
transmission image
a projection image created by X-rays or gamma-rays passing through an inspected object, based on the difference of their attenuation by the inspected object

3.2
cargo/vehicle radiographic inspection system (inspection system)
a system that makes use of X-ray or gamma-ray sources and radiation detectors to obtain transmission images of cargo or vehicles

3.3
X-ray inspection system
an inspection system that uses accelerator(s) or generator(s) to produce bremsstrahlung radiation as the source of X-ray for obtaining images

3.4
gamma-ray inspection system
an inspection system that uses radionuclide(s) as the source of gamma-ray for obtaining images

3.5
controlled area
a controlled area is any area in which specific protection measures and safety provisions are or could be required for:

a) controlling normal exposures or preventing the spread of contamination during normal working conditions; and
b) preventing or limiting the extent of potential exposures

[IAEA No. 115]

3.6
supervised area
any area not designated as a controlled area but for which occupational exposure conditions are kept under review even though specific protective measures and safety provisions are not normally needed

[IAEA No. 115]

3.7
system boundary
the outer boundary of the supervised area

3.8
total absorber
any object through which the transmitted radiation is reduced to a level at which it is not possible to distinguish from the background

3.9
steel penetration
the maximum thickness of steel (stated in mm), through which the X-rays or gamma-rays from the inspection system can be measured and distinguished from the background

3.10
wire detection
the minimum cross-section size of a wire, e.g., the diameter of a wire stated in mm, which can be measured and distinguished from the background

3.11
contrast sensitivity
the ability to distinguish a small difference of measurements in an area from a surrounding uniform background

3.12
spatial resolution
the ability to distinguish a pair of small object as separate entities

3.13
multiple energy system
an inspection system operating with two or more different spectra of radiation energy, and being capable of distinguishing different materials

3.14
material discrimination capability
certain capability of an inspection system to discriminate different classes of materials

3.15
scanning speed
the speed of the inspected object moving relative to the inspection system, or vice versa

3.16
inspection dimension
the outer dimension of the largest object which could be scanned and inspected by an inspection system

3.17
isodose contour
a perimeter around the inspection system on which all points receive equal amounts of radiation dose from the operational radiation source

3.18
ambient dose equivalent rate
the ratio of $\mathrm{d}H\mathrm{x}(10)$ by d*t*, where $\mathrm{d}H\mathrm{x}(10)$ is the increment of ambient dose equivalent in the time interval d*t*

$$\dot{H}x(10) = \frac{\mathrm{d}Hx(10)}{\mathrm{d}t}$$

The SI unit of ambient dose equivalent rate is the sievert per second ($\mathrm{Sv \cdot s^{-1}}$). Units of ambient dose equivalent rate are any quotient of the sievert or its decimal multiples or submultiples by a suitable unit of time (e.g., $\mathrm{mSv \cdot h^{-1}}$).

[IEC 60846-2009]

NOTE For a gamma-ray isotope, ambient dose equivalent rate assumes an instantaneous rate. For a pulsed x-ray–generating device, ambient dose equivalent rate is given by the time-weighted average over a full pulse cycle.

4 General characteristics of cargo/vehicle radiographic inspection system

4.1 General

The inspection systems are designed to create an image of the inspected object for an operator to detect, locate, and identify contraband hidden in cargo and/or vehicles. Such a system is generally composed of a radiation source(s), detectors, a mechanical and control system, an image processing system, a radiation safety system to protect the operators and the public against radiation, and other auxiliary devices/facilities.

The manufacturer shall state power requirements and the warm-up or set-up time of the system.

4.2 Emergency stop devices

Inspection systems shall be equipped with emergency stop devices such as emergency buttons, so that the radiation beam can be automatically shut off or the radioactive source can be automatically retracted into its shielding assembly whenever any of these devices is activated. Once any emergency stop device has been activated, the system shall not be able to restart the radiation beam automatically. Manual operation, such as inserting a key on the operator control panel and turning it to the “ON” position, is required to enable the restart of the radiation beam.

Emergency stop devices shall be installed at several locations including, but not limited to the operator control panel and in relatively close proximity to the radiation source and the detectors.

The emergency stop devices shall work in a fail-safe mode. If an emergency stop device fails, the radiation beam shall be shut off, and a failure status shall be indicated on the control panel.

For a gamma-ray system, the radioactive source shutter shall be automatically closed or the source shall be automatically retracted into its shielding assembly, in case of power failure.

4.3 Software

The system shall be able to process and display, save, backup and restore the digital radiographic images of the inspected objects and other relevant inspection data, such as container numbers, inspection date and cargo contents.

4.4 Markings

Markings shall be readable and permanently attached, including at least:

- manufacturer name;
- model number;
- unique serial number;
- function designation for control, switches, adjustments;
- radiation source and energy;
- ionizing radiation warning symbol;
- other safety warnings.

4.5 Ambient dose equivalent rate isodose contour

The manufacturer should provide an isodose contour of the ambient dose equivalent rate around the source when the inspection system is operating.

This isodose contour is provided for reference purposes only. It may change substantially based upon the motion of the system and the object placed in the beam.

4.6 Radioactive sources

Radioactive sources shall be properly shielded and protected from unauthorized access. The transportation and labelling of the radioactive sources shall comply with national and/or international requirements (e.g., IAEA No.TS-R-1 and IAEA No.RS-G-1.10).

Provisions should be made for routine leak testing of the radioactive sources, in accordance with ISO 9978:1992 in order to minimize the radiation exposure to the operator.

4.7 Safety interlocks

Safety interlocks shall be installed to prevent people from being accidentally exposed. The radiation beam can only be turned on after all the safety interlocks are in the “ON” position. If the status of any interlocks changes during operation, the radiation beam shall be terminated or shuttered. The safety interlocks shall be designed to work in fail safe mode.

The safety interlocks shall provide an interface to link additional safety devices.

4.8 Status indicators

Status indicators shall be installed to provide audible and visual warning signals to warn people of the danger of radiation exposure. These warning signals shall be started at least 5 s before the beam is turned on and remain on during the scan until the radiation beam is turned off. The configuration of status indicators shall comply with local regulations.

Ionizing radiation warning symbols or placards shall be placed along the boundary of the controlled area and the supervised area.

4.9 Monitoring system

A video monitoring system shall be provided for the operator to observe the controlled area and the supervised area.

5 Inspection system classification

The inspection system should be classified as:

- X-ray inspection system: an inspection system that uses an X-ray source for obtaining images;
- Gamma-ray inspection system: an inspection system that uses a gamma-ray source for obtaining images.

6 General test procedures

6.1 Nature of tests

Except where otherwise specified, the tests and test methods of Clauses 9, 10 and 11 in this standard shall be considered as type tests. All the tests and test methods in this standard may be considered acceptance tests based upon agreement between the user and the manufacturer.

6.2 Reference conditions and standard test conditions

Except where otherwise specified, tests shall be carried out under the standard test conditions shown in the third column of Table 1. For tests performed outside the standard test conditions, the values of temperature, pressure and relative humidity shall be stated and the appropriate corrections, if any, made to give the response under reference conditions. All tests in Clauses 7 and 8 shall be performed with the same values of these operating parameters. The values of any corrections should be stated. Reference conditions are given in the second column of Table 1.

The values in Table 1 are intended for tests performed in temperate climates. In other climates, the actual values for the test shall be stated. Similarly atmospheric pressure lower than 70 kPa may be permitted at higher altitudes.

Table 1 – Reference conditions and standard test conditions

Environment conditions	Reference conditions	Standard test conditions
Environment temperature	20 °C	15 °C to 35 °C
Relative humidity	65 %	50 % to 75 %
Atmospheric pressure	101,3 kPa	70 kPa to 106,6 kPa
Background radiation doserate	Ambient dose equivalent rate 0,1 $\mu Sv \cdot h^{-1}$	Ambient dose equivalent rate less than 0,25 $\mu Sv \cdot h^{-1}$
Ambient electromagnetic field	Negligible	Less than the lowest value that causes interference
Ambient magnetic induction	Negligible	Less than twice the value of the induction due to earth's magnetic field

6.3 Other conditions of the test

The plates, wires and sheets mentioned in Clause 7 of this standard should be fabricated with C45 steel as defined in ISO 4948-1 or equivalent. The steel test pieces may be painted or plated to eliminate dirty rust surfaces. All dimensions are specified prior to painting or plating. Wires used in this standard are round wires.

The scanning speed, source intensity, source energy, source pulse rate for systems with a linear accelerator source shall be stated for each test in Clauses 7 and 8.

7 Imaging performance tests

7.1 Steel penetration

7.1.1 Requirements

The manufacturer shall state the steel penetration expressed in millimeters as determined in 7.1.2.

7.1.2 Test method

a) The test apparatus is shown in Figure 1. The length of each side of the rectangular steel plate shall not be less than 500 mm. The bottom of the plate shall be parallel to the ground.

b) The minimum length of each side of the section of the rectangular total absorber perpendicular to the radiation beam shall not be less than 200 mm as shown in Figure 1.

c) The total absorber should be placed at the centre of the steel plate. The minimum distance between the total absorber and the nearest edge of the steel plate should not be less than 50 mm.

d) The test apparatus should be placed perpendicular to the radiation beam at the centre of the inspection dimension.

e) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

f) If the total absorber is discernible in the scanned image, then increase the thickness of the steel plate and scan the apparatus again until the total absorber is not discernible in the scanned image. The increment of the thickness shall be 10 mm.

g) The steel penetration is the sum of the thicknesses of the steel plates, behind which the total absorber is discernible in the scanned image.

h) Additional measurements in other positions can be made based upon agreement between the user and the manufacturer.

i) A statistical method with multiple tests for the determination of steel penetration may be used based upon agreement between the user and the manufacturer.

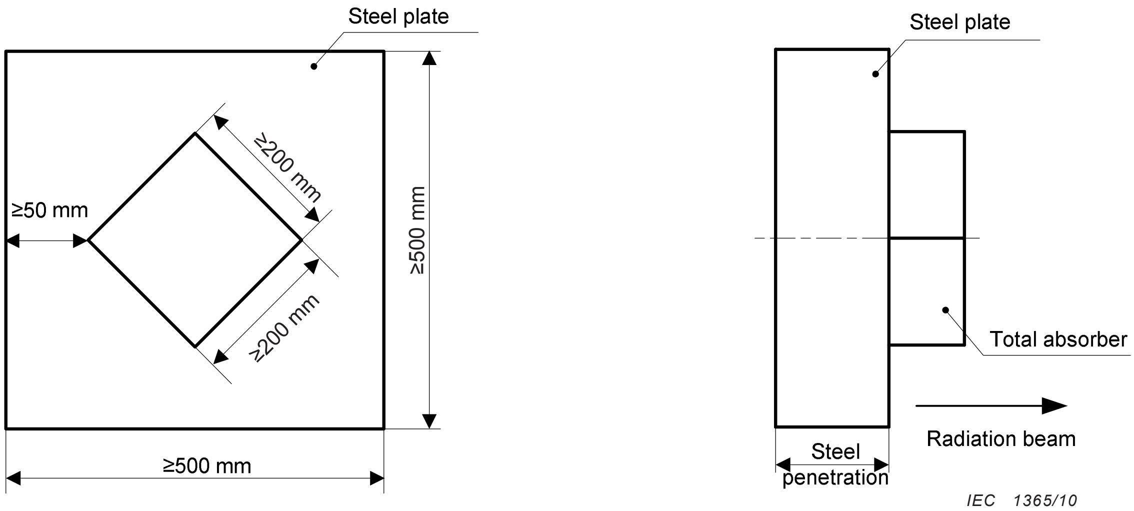

Figure 1 – Steel penetration testing apparatus

7.2 Wire detection

7.2.1 Requirements

The manufacturer shall state the wire detection expressed in millimeters as determined in 7.2.2.

7.2.2 Test method

a) One steel wire, or more such wires of different diameters shall be placed in air or behind a steel plate with a thickness of 100 mm. The test apparatus with steel plate is shown in Figure 2. The length of each side of the rectangular steel plate shall not be less than 500 mm. The bottom of the plate shall be parallel to the ground. Note that a low atomic number material plate may be used to support the wire(s) when they are placed in air.

b) The distance between the ends of a steel wire and the nearest edge of the steel plate, if any, shall not be less than 50 mm. The distance between any two wires shall not be less than 50 mm. All the wires used shall be at least 100 mm long and oriented at 45º to the sides of the plate.

c) The test apparatus should be placed perpendicular to the radiation beam at the centre of the inspection dimension.

d) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

e) If all the steel wires are discernible in the scanned image, then decrease the diameters of the steel wires and scan the apparatus again until at least one of the steel wires is not discernible in the scanned image. The decrement of the diameter shall be 0,1 mm.

f) The wire detection is the diameter of the thinnest wire, which is discernible in the scanned image.

g) Additional measurements with other thicknesses of the steel plate may be made based upon agreement between the user and the manufacturer.

h) Additional measurements at other positions may be made based upon agreement between the user and the manufacturer.

i) Wires may also be shaped as circles or sinusoids based upon agreement between the user and the manufacturer.

j) A statistical method with multiple tests for the determination of wire detection may be used based upon agreement between the user and the manufacturer.

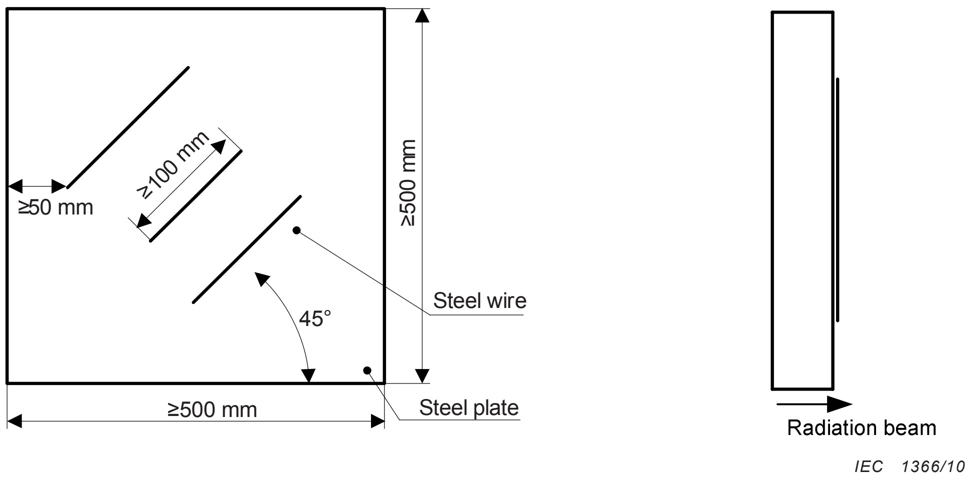

Figure 2 – Wire detection testing apparatus

7.3 Contrast sensitivity

7.3.1 Requirements

The manufacturer shall state the contrast sensitivity expressed in percentage as determined in 7.3.2.

7.3.2 Test method

a) One rectangular steel sheet, or more such sheets of different thicknesses, shall be placed behind a steel plate with a thickness of 100 mm. The test apparatus with steel plate is shown in Figure 3. The length of each side of the rectangular steel plate shall be at least 500 mm. The bottom of the plate shall be parallel to the ground.

b) The length of the each side of the sheet(s) shall not be less than 100 mm and oriented at 45º to the side of the plate as shown in Figure 3.

c) The minimum distance between a steel sheet and the nearest edge of the steel plate shall not be less than 50 mm. The minimum distance between any two steel sheets shall not be less than 50 mm.

d) The test apparatus should be placed perpendicular to the radiation beam at the centre of the inspection dimension.

e) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

f) If all the steel sheets are discernible in the scanned image, then decrease the thickness of the steel sheet and scan the apparatus again until at least one of the steel sheets is not discernible in the scanned image. The decrement of the thickness shall be 0,1 mm.

g) The contrast sensitivity is the ratio (expressed as a percentage) of the thickness of the thinnest steel sheet, which is discernible behind the steel plate of a specified thickness, to the thickness of the steel plate.

h) Additional measurements with steel plate of other thicknesses may be made based upon agreement between the user and the manufacturer.

i) Additional measurements at other positions may be made based upon agreement between the user and the manufacturer

j) A statistical method with multiple tests for the determination of contrast sensitivity may be used based upon agreement between the user and the manufacturer.

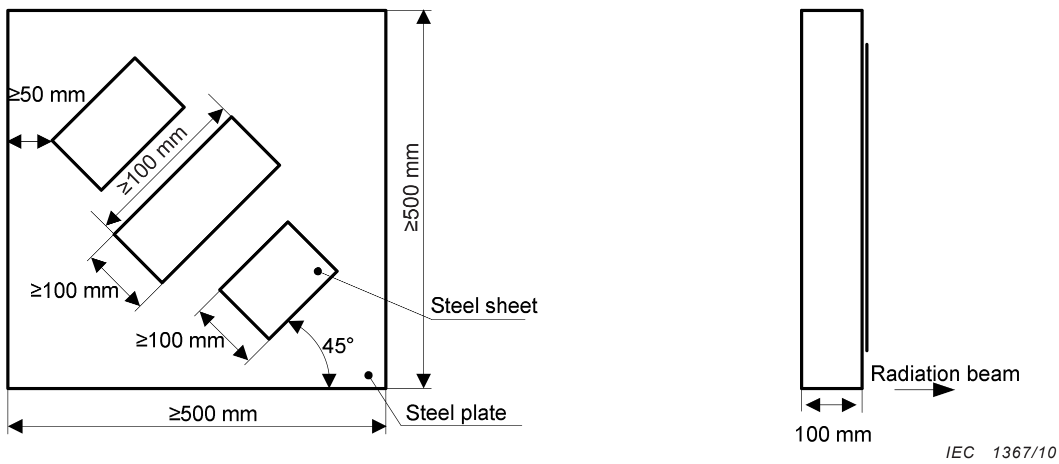

Figure 3 – Contrast indicator test apparatus

7.4 Spatial resolution

7.4.1 Requirements

The manufacturer shall state the spatial resolution expressed in millimeters as determined in 7.4.2.

7.4.2 Test method

a) Three sets of test wires should be used in this test and for each of the three sets, two or more steel wires of diameter 'x' mm spaced at '2x' mm (i.e., a space of 'x mm between edges of the wires) should be placed in air. The test apparatus is shown in Figure 4. Note that a low atomic number material plate may be used to support wires and the bottom of the plate shall be parallel to the ground.

b) All the wires used shall be at least 100 mm long. The three sets of the test wires shall be oriented respectively parallel, perpendicular and at 45º to the bottom of the plate.

c) The test apparatus shall be placed perpendicular to the radiation beam at the centre of the inspection dimension.

d) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

e) If all the steel wires are distinguished as separated entities in the image, then decrease the diameter and scan the apparatus again until the steel wires cannot be distinguished in the image. The decrement of the diameter shall be 0,1 mm.

f) If there are two or more wires of diameter 'x' mm spaced at '2x' mm (i.e., a space of 'x mm between edges of the wires), then the smallest value of 'x' mm that results in the number of tested wires being distinguishable in the image defines the spatial resolution of the inspection system under test.

g) Additional measurements with steel plate used as blocking material can be made based upon agreement between the user and the manufacturer. The thickness of the steel plate shall be stated.

h) Additional measurements at other positions can be made based upon agreement between the user and the manufacturer.

i) Additional measurements in other orientations of the wires can be made based upon agreement between the user and the manufacturer.

j) A statistical method with multiple tests for the determination of spatial resolution may be used based upon agreement between the user and the manufacturer.

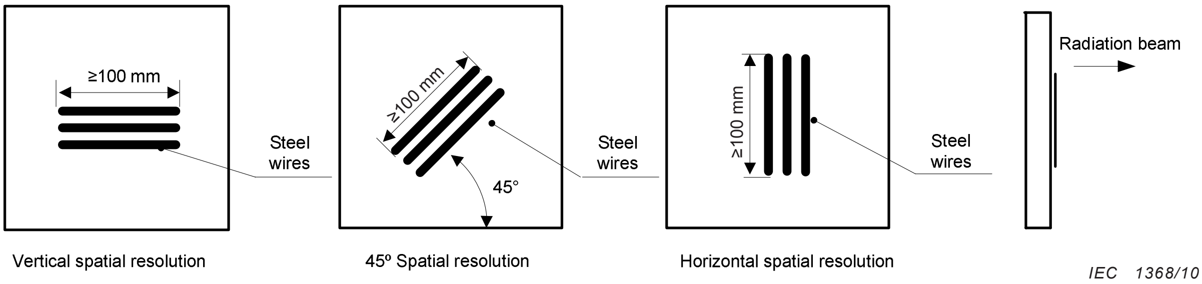

Figure 4 – Spatial resolution test apparatus

7.5 Material discrimination capability

7.5.1 Requirements

The manufacturer shall state the material discrimination capability of a multiple energy system, if the system has such a capability.

7.5.2 Test method

a) The test apparatus shall consist of 4 testing samples made of lead, steel, aluminium, and graphite respectively.

b) The dimensions of the samples are shown in Figure 5, in which the stepped samples of different thicknesses are used to cover the whole range of inspection. The specified stepped thicknesses for each material are shown in Table 2.

Table 2 – Thicknesses for each material

Material \ Thickness mm	T1	T2	T3	T4	T5
lead	10	20	40	60	100
steel	15	30	60	90	150
aluminium	40	80	160	250	400
graphite	100	200	400	600	N/A

c) Each edge of every rectangular surface of all stepped samples shall not be less than 200 mm.

d) A testing sample should be placed perpendicular to the radiation beam (refer to Figure 5) at the centre of the inspection dimension. The length of the test samples are oriented parallel to the ground.

e) Scan the apparatus and inspect the image using image processing tools available on the inspection system. Record the scanning speed and other particulars as stated in 6.3.

f) Different materials should be displayed in different hues in the scanned image of the inspection system. A material with different thickness should be displayed in the same hue. Additional software may be used for analysis of the image colour.

g) A system that can distinguish one material from another material (Table 2) shall be able to display the same material with at least two different thicknesses as the same hue. A system that can discriminate different materials shall be able to distinguish at least two materials from any other materials in Table 2.

h) Additional measurements with blocking material can be made based upon agreement between the user and the manufacturer.

i) A statistical method with multiple tests for the determination of material discrimination capability may be used based upon agreement between the user and the manufacturer.

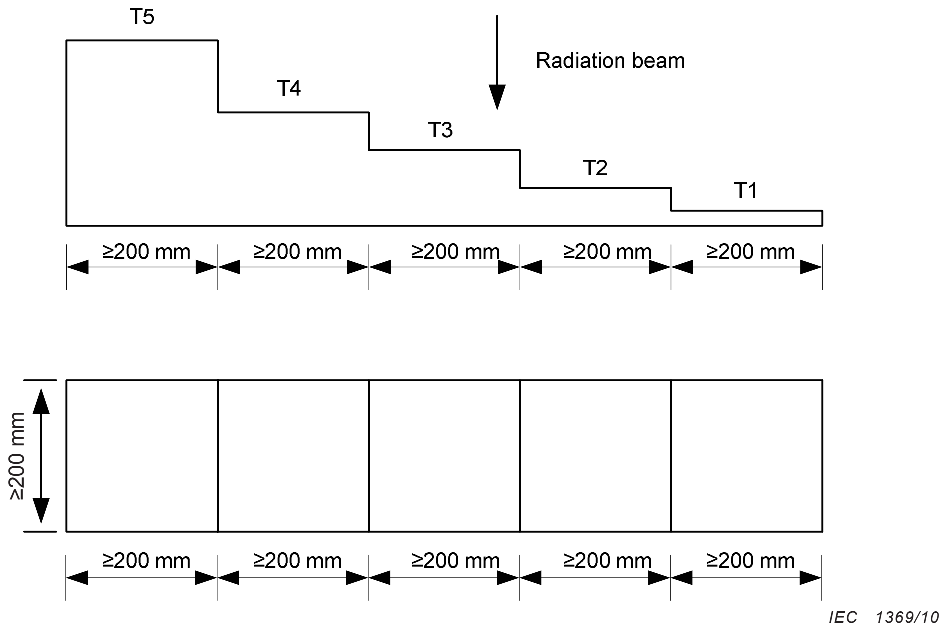

Figure 5 – A test sample for material discrimination capability test

8 Radiological safety tests

8.1 General

The radiological safety test shall be performed when the radiation source in the inspection system works at its highest operational radiation level, and the other test conditions shall be the same as for the specified imaging performance test in Clause 7.

The scattered radiation from the scanned object will often increase the ambient dose equivalent rate around the inspection system. So a container, vehicle, or pallet, whichever is most appropriate for the inspection system, is recommended as the reference scanned object for the radiological safety test. A different reference scanned object can be used based upon agreement between the user and the manufacturer.

The manufacturer shall use the ambient dose equivalent (rate) measurement instrument appropriate for the radiation source(s) used in the system and shall provide the instrument type, manufacturer and serial number, and calibration certification.

8.2 Ambient dose equivalent rate isodose contour

8.2.1 Requirements

The ambient dose equivalent rate isodose contour of 2,5 $\mu Sv \cdot h^{-1}$ around the system shall be measured and provided.

This set of measurements is required for any system that uses distance and/or a supervised area as part of the radiation control of the system. Where the ambient dose equivalent rate at 5 cm outside all reachable surfaces of the system is less than 2,5 $\mu Sv \cdot h^{-1}$ above natural background, this test is not required.

8.2.2 Test method

a) The system shall be tested in a static mode to make measurements more accurate and repeatable.

b) Measure and record the ambient dose equivalent rate in the primary forward direction at 1 m away from the radiation source as its radiation output level.

c) Place the referenced scanned object in the scanned position.

d) Move the radiation measurement instrument in and out along each angle direction specified in Figure 6 to find the position where the ambient dose equivalent rate is 2,5 μSv·h^{-1} above natural background. The instrument shall be at 1 m ± 0,1 m above the ground level, and the angle directions from 0° to 360°. Measurements should be taken at appropriate angle intervals as indicated in Figure 6.

e) Draw the lines to connect the positions in sequence to plot the ambient dose equivalent rate isodose contour of 2,5 μSv·h^{-1} for the system.

f) Additional measurements at different angles or heights can be made based upon agreement between the user and the manufacturer.

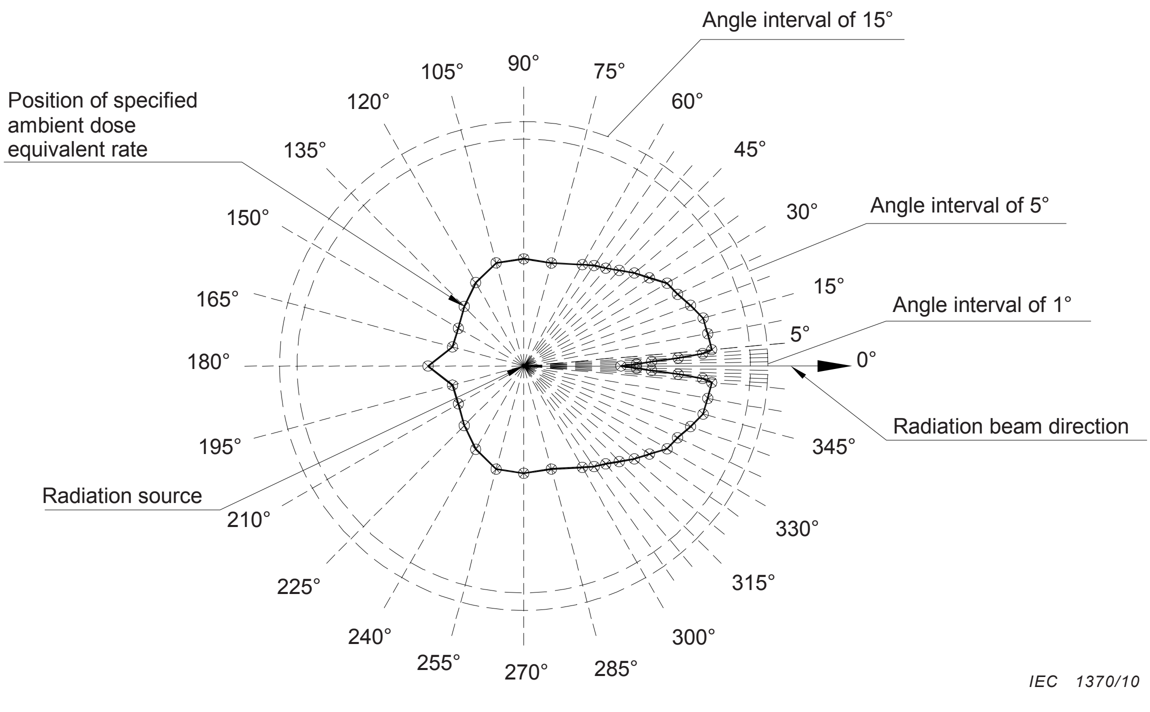

Figure 6 – Layout of an example ambient dose equivalent rate isodose contour

8.3 Ambient dose equivalent rate on the system boundary

8.3.1 Requirements

Along the system boundary stated by the manufacturer, the maximum value of the ambient dose equivalent rate shall not be higher than 2,5 μSv·h^{-1}, above natural background during the scan, however, different national regulatory limits may apply.

8.3.2 Test method

a) Measure and record the ambient dose equivalent rate in the primary forward direction at 1 m away from the radiation source as its radiation output level.

b) Place the referenced scanned object in the scanned position.

c) Measure and record the ambient dose equivalent rate at 1 m ± 0,1 m above the ground level along the system boundary stated by the manufacturer.
d) If the radiation source in the inspection system moves during the scan, the ambient dose equivalent rate at each specific location on the system boundary shall be the maximum reading during this scan.
e) Additional measurements in other positions can be made based upon agreement between the user and the manufacturer. If the beam stop does not cover the full height of the radiation beam, additional measurements shall be made at occupied positions not shielded by the beam stop where the ambient dose equivalent rate may be higher than 2,5 $\mu Sv \cdot h^{-1}$.
f) The ambient dose equivalent rates on the system boundary can also be measured with another reference scanned object in the scanned position based upon agreement between the user and the manufacturer.

8.4 Ambient dose equivalent rate at the operating positions

8.4.1 Requirements

The maximum ambient dose equivalent rate at the operating positions during the scan shall be not higher than 1,0 $\mu Sv \cdot h^{-1}$ above natural background, however, different national regulatory limits may apply.

8.4.2 Test method

a) Measure and record the ambient dose equivalent rate in the primary forward direction at 1 m away from the radiation source as its radiation output level.
b) Place the reference scanned object in the scanned position.
c) Measure and record the ambient dose equivalent rate at the operating positions for the crew during the scan, e.g., the control panel and the image inspection station.
d) If the radiation source in the inspection system moves during the scan, the ambient dose equivalent rate at the operating positions shall be the maximum reading during this scan.
e) The ambient dose equivalent rates at the operating positions can be measured also with other reference scanned object in the scanned position based upon agreement between the user and the manufacturer.

8.5 Ambient dose equivalent to the driver

8.5.1 Requirements

If the driver stays in the scanned vehicle during the scan, the ambient dose equivalent to the driver shall not be higher than 5 μSv per scan, however, different national regulatory limits may apply.

8.5.2 Test method

a) Measure and record the ambient dose equivalent rate in the primary forward direction at 1 m away from the radiation source as its radiation output level.
b) Place passive dosimeters or other cumulative dose meters as appropriate at the driver position.
c) Measure and record the cumulative ambient dose equivalent from a minimum of 10 scans at the normal inspection speed.
d) The result of the cumulative dose above the natural background divided by the number of scans represents the ambient dose equivalent to the driver per scan.

8.6 Ambient dose equivalent to the object being inspected

8.6.1 Requirements

The ambient dose equivalent to the object being inspected shall not be higher than 1 mSv per scan, however, different national regulatory limits may apply.

8.6.2 Test method

a) Measure and record the ambient dose equivalent rate in the primary forward direction at 1 m away from the radiation source as its radiation output level.
b) Place passive dosimeters or other cumulative dose meters as appropriate at the centre of the inspection dimension.
c) Measure and record the cumulative ambient dose equivalent from a minimum of 10 scans at the normal scanning speed.
d) The result of the cumulative dose above the natural background divided by the number of scans represents the ambient dose equivalent to the object being inspected per scan.
e) Additional measurements in other positions can be made based upon agreement between the user and the manufacturer.

9 Electrical safety tests

9.1 Equipment ground protection

9.1.1 Requirements

Inspection systems shall have protective circuit and the resistance between the system case and protective earthing terminal shall not exceed 0,1 Ω (see IEC 61010-1:2001, 6.5.1.3).

9.1.2 Test method

Use a ground meter to measure the resistance between the system case and PE terminal with a test current of 25 A.

9.2 Insulation resistance

9.2.1 Requirements

Under the test condition shown in Table 1, the insulation resistance between the protective circuit and each phase of the power of electric equipment with independent power supply in the inspection system shall not be less than 1 MΩ (see IEC 60204-1:2005, 18.3).

9.2.2 Test method

The insulation resistance shall be measured at 500 V d.c. between the protective circuit and each phase of the main supply. The result shall not be less than 1 MΩ.

9.3 Voltage test

9.3.1 Requirements

Electric equipment shall be tested according to requirements in Table 3 and there shall be no breakdown or repeated arc-over during the test.

Components and devices that are not rated to withstand the test voltage shall be disconnected during testing.

Table 3 – Test voltage

Test voltage V (virtual value of AC or DC)	Duration of test runs s
1 000	≥1

(See IEC 60204-1:2005, 18.4.)

9.3.2 Test method

Test voltage shall be applied between the power circuit conductors and protective circuit, and gradually increased from 0 V to 1 000 V in 10 s and kept at 1 000 V for at least 1 s. The requirements are satisfied if no disruptive discharge occurs.

9.4 Electric shock protection

9.4.1 Requirements

Components of the inspection system shall provide electric shock protection under normal working conditions. Touchable parts shall not be charged when power is applied to the system. Voltage between touchable parts and the safety grounding terminal, or voltage between any two touchable parts less than 1,8 m apart on the same equipment, shall be no more than 33 V (virtual value 33 V, peak value 46,7 V, or DC 70 V) (see IEC 61010-1:2001, 6.3).

9.4.2 Test method

A resistance of 2 000 Ω connected in parallel to an AC voltmeter and the voltage value between all the directly-palpable elements to be tested and both ends of the safety ground terminal shall be measured.

NOTE Electrical safety tests should be made prior to delivery of each type system. Additional tests can be made based upon agreement between the user and the manufacturer.

10 Electromagnetic compatibility

10.1 Requirements

The electromagnetic emission limit value of relevant units in an inspection system shall be in accordance with the emission limit value specified in IEC 61000-6-4.

The immunity to disturbance of relevant units in inspection systems shall be in accordance with the requirements specified in IEC 61000-6-2 (Table 1, subclause 1.3; Table 2, subclauses 2.2 and 2.3; Table 3, subclauses 3.2 and 3.3; Table 4, subclauses 4.2, 4.3, 4.4 and 4.5; Table 5, subclause 5.2). The safety interlock equipment shall function properly during and after testing.

10.2 Test method

The electromagnetic compatibility test shall be performed at 10 m from the radiation supervised area of the system according to the test condition prescribed in Clauses 6 and 9 in IEC 61000-6-4. The result of the test shall be in accordance with the requirements in 10.1.

The immunity test shall be conducted according to the test condition and the test requirements prescribed in Clauses 6 and 9 in IEC 61000-6-2. The result of the test shall be in accordance with the requirements in 10.1.

11 Environmental requirements

11.1 Requirements

The manufacturer shall state the environmental adaptability of the inspection system or the components, including but not limited to temperature, humidity, moisture and dust protection. The safety related components shall function properly in the full range of working conditions stated by manufacturer.

11.2 Test method

The test method should be designed based upon agreement between the user and the manufacturer.

12 Documentation

Some documents, including but not limited to the following information, shall be provided with each system:

- Manufacturer's name or registered trademark.
- Type of system, serial number.
- Tests reports.
- Instruction manuals.
- Certificate of the source.
- Confirmation of compliance with this standard.

Bibliography

IEC 60846-1:2009, *Radiation protection instrumentation – Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation – Part 1: Portable workplace and environmental meters and monitors*

IAEA Safety Series No.115, *International basic safety standards for protection against ionizing radiation and for the safety of radiation sources*

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