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Radiation protection — Apparatus for industrial gamma radiography — Specifications for performance, design and tests

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National foreword

This British Standard is the UK implementation of ISO 3999:2004. It supersedes BS 5650:1978 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee NCE/2, Radiation protection and measurement.

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INTERNATIONAL STANDARD

ISO 3999

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Radiation protection — Apparatus for industrial gamma radiography — Specifications for performance, design and tests

Radioprotection — Appareils pour radiographie gamma industrielle — Spécifications de performance, de conception et d'essais

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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

ISO 3999 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

This second edition cancels and replaces ISO 3999-1:2000, of which it constitutes a minor revision.

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INTERNATIONAL STANDARD ISO 3999:2004(E)

Radiation protection — Apparatus for industrial gamma radiography — Specifications for performance, design and tests

1 Scope

This International Standard specifies the performance, design and test requirements of apparatus for gamma radiography with portable, mobile and fixed exposure containers of the various categories defined in Clause 4.

It applies to apparatus designed to allow the controlled use of gamma radiation emitted by a sealed radioactive source for industrial radiography purposes, in order that persons will be safeguarded when the apparatus is used in conformity with the regulations in force regarding radiation protection.

It is emphasised, however, that so far as transport of apparatus and sealed radioactive source is concerned, compliance with this International Standard is no substitute for satisfying the requirements of relevant international transport regulations (IAEA Regulations for the safe transport of radioactive materials: IAEA-STI-PUB 998, Safety Standards Series No. ST-1 and No. ST-2, and/or the relevant national transport regulations).

The operational use of apparatus for industrial gamma radiography is not covered by this International Standard. Users of this equipment shall comply with national regulations and codes of practice.

2 Normative references

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

ISO 361, *Basic ionizing radiation symbol*

ISO 2919:1999, *Radiation protection — Sealed radioactive sources — General requirements and classification*

ISO 7503-1, *Evaluation of surface contamination — Part 1: Beta-emitters (maximum beta energy greater than 0,15 MeV) and alpha-emitters*

IAEA-STI-PUB 998 (Safety Standards Series No. ST-1):1996, *Regulations for the safe transport of radioactive material*

IAEA-STI-PUB 998 (Safety Standards Series No. ST-2):1996, *Advisory Material for the IAEA Regulations for the safe Transport of Radioactive Material Safety Guide*

IEC 60068-2-6, *Environmental testing — Part 2: Tests — Test Fc: Vibration (sinusoidal)*

IEC 60068-2-47, *Environmental testing — Part 2-47: Test methods — Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests*

IEC 60846, *Radiation protection instrumentation — Ambient and/or directional dose equivalent (rate) meters and/or monitors for beta, X and gamma radiation*

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IEC 61000-6-1, *Electromagnetic compatibility (EMC) — Part 6: Generic standards — Section 1: Immunity for residential, commercial and light-industrial environments*

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

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Certain terms are illustrated in Figures 1 to 5 which, however, do not purport to illustrate typical or preferred designs.

3.1
ambient equivalent dose rate
dose rate measured as an average over the sensitive volume of the detector

NOTE 1 Measurements of the ambient equivalent dose rate shall be made at 1 m from the surface and additionally at the surface of the exposure container or at 50 mm from the surface.

NOTE 2 The limits are given in 5.3. The maximum cross-sectional areas of the detectors to be used are given in 6.4.1.2.

cf. ICRU 51.

3.2
apparatus for industrial gamma radiography
apparatus including an exposure container, a source assembly, and as applicable, a remote control, a projection sheath, an exposure head, and accessories designed to enable radiation emitted by a sealed radioactive source to be used for industrial radiography purposes

NOTE In the following text, an “apparatus for industrial gamma radiography” can be used for any means of non-destructive testing using gamma radiation.

3.3
automatic securing mechanism
automatically activated mechanical device designed to restrict the source assembly to the secured position

3.4
beam limiter
shielding device located at the working position designed to reduce the radiation dose rate in directions other than the directions intended for use

NOTE The beam limiter may be designed to be used in conjunction with an exposure head or may incorporate an exposure head as an integral part of the device.

3.5
control cable
cable or other mechanical means used to project and retract the source assembly out from and into the exposure container by means of remote control

NOTE The control cable includes the means of attachment to the source holder.

3.6
control-cable sheath
rigid or flexible tube for guiding the control cable from the remote control to the exposure container and for providing physical protection to the control cable

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NOTE The control-cable sheath includes the necessary connection(s) for attachment to the exposure container and to the remote control.

3.7
exposure container
shield, in the form of a container, designed to allow the controlled use of gamma radiation and employing a source assembly

3.8
exposure head
device which locates the sealed source included in the source assembly, in the selected working position, and prevents the source assembly from projecting out of the projection sheath

3.9
lock
mechanical device with a key used to lock or unlock the exposure container

3.10
locked position
condition of the exposure container and source assembly in the secured and locked position

3.11
maximum rating
maximum activity, expressed as in 7.1.3, of a sealed source specified for a given radionuclide by the manufacturer, marked on the exposure container and not to be exceeded if the apparatus is to conform to this International Standard

3.12
projection sheath
flexible or rigid tube for guiding the source assembly from the exposure container to the working position and having the necessary connections for attachment to the exposure container and to the exposure head, or including the exposure head itself

3.13
remote control
device enabling the source assembly to be moved to and from a working position by operation from a distance away from the exposure container

NOTE The remote control includes the control mechanism and, where applicable, also the control cable, the control-cable sheath and the necessary connections and attachments.

3.14
reserve sheath
sheath containing the length of the control cable, necessary for the projection of the source assembly

3.15
sealed radioactive source
radioactive source sealed in a capsule or having a bonded cover, the capsule or cover being strong enough to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed

NOTE In the following text, the term “sealed source” is used instead of “sealed radioactive source” for simplification.

(cf. 3.11 of ISO 2919:1999)

3.16
secured position
condition of the exposure container and source assembly, when the sealed source is fully shielded and restricted to this position within the exposure container

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NOTE In the secured position, the exposure container may be unlocked.

3.17
simulated source
source whose structure is the same as that of the sealed radioactive source but not containing any radioactive material

3.18
source assembly
source holder with a sealed source attached or included

NOTE In cases where the sealed source is directly attached to the control cable without the use of a source holder, the source assembly is the control cable with the sealed source attached. In cases where the sealed source is not attached to the control cable nor included within the source holder, the sealed source is the source assembly. In the case where a simulated source is attached to or included with a source holder or control cable, this becomes a simulated source assembly.

3.19
source holder
holder, or attachment device, by means of which a sealed source or simulated source can be directly included in the exposure container (category I apparatus), or fitted at the end of the control cable (category II apparatus)

NOTE Source holders may be an integral part of the source assembly or may be capable of being dismantled for sealed source replacement.

3.20
working position
condition of the exposure container and source assembly, when in the position intended for performance of industrial gamma radiography

4 Classification

4.1 Classification of exposure containers according to the location of the source assembly when the apparatus is in the working position

4.1.1 Category I

Exposure container from which the source assembly is not removed for exposure (e.g. see Figure 1).

4.1.2 Category II

Exposure container from which the source assembly is projected out through a projection sheath to the exposure head for exposure. The projection is remotely operated (e.g. see Figure 2).

4.1.3 Category X

Apparatus for gamma radiography designed for special applications where the unique nature of the special application precludes full compliance with this International Standard, for example:

— self propelled intra-tubular gamma radiography apparatus (pipe-line crawler);

— gamma radiography apparatus for underwater use.

The exposure container shall comply with this International Standard to the maximum extent possible. Exceptions and items of non-compliance shall be described in the addenda.

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4.2 Classification of exposure containers according to their mobility

4.2.1 Class P

Portable exposure container, designed to be carried by one or more persons. The mass shall be not more than 50 kg.

4.2.2 Class M

Mobile, but not portable, exposure container designed to be moved easily by suitable means provided for the purpose.

4.2.3 Class F

Fixed installed exposure container, or one with mobility restricted to the confines of a defined working location.

5 Specifications

5.1 General design requirements

5.1.1 Apparatus for industrial gamma radiography shall be designed for the conditions likely to be encountered in use.

5.1.2 The design of class P and M apparatus shall ensure that the apparatus withstands the effects of corrosion under the intended conditions of use.

5.1.3 The design of class P and M apparatus shall ensure continued operation under environmental conditions of moisture, mud, sand and other foreign materials.

NOTE If feasible, a test for continued operation under environmental conditions of moisture, mud, sand and other foreign materials, will be developed and will be issued as an addendum.

5.1.4 The design of the apparatus shall ensure satisfactory operation over the temperature range −10 °C to 45 °C.

5.1.5 The operating voltage and the insulation resistance of electric circuits of power-operated apparatus for industrial gamma radiography shall comply with the relevant IEC standards.

5.1.6 The design of the apparatus shall ensure that any non-metallic components (e.g. rubber, plastics, jointing and sealing compounds, lubricants) will not suffer any damage from radiation that will diminish the safety of the apparatus during its design life as specified by the manufacturer.

5.1.7 Putting the exposure container outside or into the secured position shall be possible without bringing parts of the human body into the beam of radiation.

5.1.8 Connecting or disconnecting the projection sheath and/or the remote control from the exposure container shall be possible without bringing parts of the human body into areas where the ambient equivalent dose rate exceeds 2 mSv/h (200 mrem/h).

5.1.9 The design of any replacement component, including the source assembly, shall ensure that its interchange with the original component will not compromise the design safety features of the apparatus.

5.1.10 For class P and M exposure containers, the design of the apparatus shall provide appropriate means for the secure mounting of the remote control and projection sheath (if applicable) to the exposure container in different positions of use.

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5.1.11 The exposure container shall be designed in such a way as to discourage dismantling by unauthorized personnel. Those components which cause the source assembly to be retained in the secured or locked position shall be designed so that they can only be dismantled by using a special tool or removing a seal or removing a label that gives warning of the significance of the dismantling. The apparatus shall be designed so that it is impossible for the source assembly to be extracted from the back of the exposure container whilst operating the apparatus, or connecting or disconnecting the remote control.

5.1.12 All materials providing radiological protection shall maintain their shielding properties at a temperature of 800 °C. When using materials with melting temperatures below 800 °C, the designer shall take into account the need to completely contain the shielding materials at this temperature. When using materials with melting temperatures above 800 °C, the designer shall take into account the possible eutectic alloying of the shielding materials with surrounding materials at temperatures below 800 °C.

5.1.13 Wherever depleted uranium is used for shielding, it shall be clad or encased with a non-radioactive material of sufficient thickness to absorb the emitted beta radiation and to limit corrosion and prevent contamination. The source tunnel through the depleted uranium shall also be clad or encased with a non-radioactive material to limit abrasion, corrosion and consequential deformation. Limitation of abrasion shall be demonstrated by satisfactory performance of a test consisting of the examination of the simulated source assembly, to demonstrate that there is no abrasion of the source tunnel which could lead to contamination by depleted uranium.

5.1.14 The exposure container shall be designed in such a way as to maintain its shielding properties specified in Table 1 under the conditions of the tests specified in 5.8, except the accidental-drop test (5.8.4.6).

5.2 Sealed sources

Sealed sources shall be in compliance with the requirements of ISO 2919.

5.3 Ambient equivalent dose-rate limits in the vicinity of exposure containers

Exposure containers shall be made in such a way that, when in the locked position with the protective cap installed, if applicable, and loaded with a sealed source corresponding to the maximum rating, the ambient equivalent dose rate, when checked according to the shielding-efficiency test described in 6.4.1, shall not exceed the limit in column (4) and one or other of the limits in columns (2) and (3) of Table 1 for the appropriate class of exposure container.

Table 1 — Ambient equivalent dose-rate limits

1	2	3	4
Class	**Maximum ambient equivalent dose rate,** mSv/h (mrem/h)		
	On external surface of container	At 50 mm from external surface of container	At 1 m from external surface of container
P	2 (200)	0,5 (50)	0,02 (2)
M	2 (200)	1 (100)	0,05 (5)
F	2 (200)	1 (100)	0,1 (10)

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5.4 Safety devices

5.4.1 Securing devices

5.4.1.1 Locks

All exposure containers shall be equipped with a key-operated integral lock to ensure that the change of state of the exposure container from the locked position can only be achieved by a manual unlocking operation using the key.

The lock shall be either lockable without the key, or of a type from which the key can only be withdrawn when the container is in the locked position. The lock shall retain the exposure container and the source assembly in the secured position and shall not, if the lock is damaged, prevent the source assembly when it is in the working position from being returned to the secured position. The lock shall comply with the lock-breaking tests described in 5.8.4.2 and 6.4.2.

5.4.1.2 Operation of the automatic securing mechanism

The exposure container shall be designed so that it is only possible to release the automatic securing mechanism by means of a deliberate operation on the exposure container, which may be remotely activated.

When the source assembly is returned to the location of the secured position, the exposure container and the source assembly shall go automatically to the secured position.

It shall not be possible to lock the exposure container unless the source assembly is in the secured position.

For a category II exposure container, it shall not be possible to release the source assembly from the secured position unless a secure attachment is made between the control cable and the source assembly, between the control-cable sheath and the exposure container, and between the projection sheath and the exposure container.

For an exposure container using a remote control, it shall not be possible to completely detach the remote control unless the exposure container is in the secured position.

5.4.2 Indications of secured position or not

The apparatus shall be designed such that it is possible for the operator to determine if the source holder is in the secured position from a distance of at least 5 m. If these indications are on the container, they shall be clearly recognizable at a distance of 5 m in the direction of the attachment of the remote control in normal conditions of use[1)]. If colours are used, green shall indicate that the source holder is in the secured position and red shall indicate that the source holder is not. Colours shall not be the sole means of identification. All indications shall be clear and reliable.

Manufacturers must specify in their instructions for use of the apparatus that a radiation survey meter must be used to determine the position of the sealed source. The requirements for the radiation survey meter to be properly calibrated and functional shall be in accordance with IEC 60846.

Refer to IEC 60846 for the requirements on calibration and maintenance of radiation survey meters.

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1) Some national regulatory authorities require the provision of sealed source position indicators on the exposure container. To fully comply with such requirements, it would be necessary to detect that the sealed source is in the position indicated.

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