
Specification for

Apparatus for gamma radiography

Spécification des appareils de radiographie

Spezifikation für Einrichtungen für Gammaradiographie

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National foreword

This British Standard has been prepared under the direction of the Nuclear Engineering Standards Committee. It is identical with ISO 3999 'Apparatus for gamma radiography — Specification', and supersedes BS 4097, which is now withdrawn. The United Kingdom has taken part in the preparation of ISO 3999 by ISO Technical Committee TC 85, Nuclear energy, and the British Standards Institution was responsible for the Working Group that developed the draft standard.

The reader of the standard should bear in mind the duties placed upon designers, manufacturers and suppliers in the United Kingdom by Section 6 of the Health and Safety at Work, etc. Act 1974.

The actual use of apparatus is outside the scope of the standard and users in the United Kingdom should therefore refer to current national regulations for the use of ionizing radiation.

Terminology and conventions. The text of the international standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards; attention is therefore drawn to the following.

The comma has been used throughout as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words 'International Standard' appear, referring to this standard, they should be interpreted as 'British Standard'.

Additional information. With reference to the marking requirement in 7.1(d), all containers should be marked in the following manner with both the number of this British Standard and the number of the ISO standard:

'BS 5650 [ISO 3999]'

NOTE. The exposure rate of 1 R/h specified in 5.8 is equivalent in SI units to 258 $\mu\text{C}/(\text{kg h})$; see also table 1.

Cross-references. The following international standards are referred to in the text and for each there is a corresponding British Standard; these are as listed below:

International standard	Corresponding British Standard
ISO 3-1973	BS 2045 : 1965 Preferred numbers (Technically equivalent)
ISO 361-1975	BS 3510 : 1968 A basic symbol to denote the actual or potential presence of ionizing radiation (Technically equivalent)
ISO 2919*	BS 5288 : 1976 Sealed radioactive sources (Technically equivalent)

NOTE. The reference to ISO 2855, for which there is no corresponding British Standard, constitutes informative matter only, and since no mandatory requirements are involved, the validity of this British Standard is not affected.

*With reference to footnote 3, clause 2, ISO 2919 will be published shortly.

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0 INTRODUCTION

Resulting from advances made in the nuclear energy field and the consequent increasing availability of radionuclides, the use and importance of gamma radiography for industrial purposes is now well established.

This International Standard applies to apparatus designed to permit the use of gamma radiation emitted by a sealed radioactive source for the purpose of industrial radiography¹⁾.

The purpose of this International Standard is to specify the performance requirements which such apparatus should meet in order that persons will be safeguarded when the apparatus is in normal use in conformity with the regulations in force regarding radiation protection.

It is emphasized, however, that so far as transport of apparatus is concerned, compliance with this International Standard is no substitute for satisfying the requirements of the relevant transport regulations.

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the constructional requirements of portable, mobile and fixed apparatus for gamma radiography of the following categories designed to allow the controlled use of radiation for industrial purposes :

- a) **Category I** : An exposure container from which the sealed source is not removed for exposure. The beam of radiation is exposed by opening a shutter or rotating the sealed source within the container or by other means. (See figure 1.)
- b) **Category II** : An exposure container from which the sealed source is projected out of the container through a projection sheath to the exposure head for exposure, either mechanically, electrically, pneumatically or by other means by an operator at a distance from the exposure head. (See figure 2.)¹⁾

The operational usage of exposure containers is not covered by this International Standard.

NOTE — If it is proposed to use these exposure containers as transport packages, they should comply with current International Atomic Energy Agency Regulations for the safe transport of radioactive materials²⁾ and/or the relevant national transport regulations.

2 REFERENCES

- ISO 3, *Preferred numbers — Series of preferred numbers.*
- ISO 361, *Basic ionizing radiation symbol.*
- ISO 2855, *Radioactive materials — Packagings — Tests for contents leakage and radiation leakage.*
- ISO 2919, *Sealed radioactive sources — Classification.*³⁾

3 DEFINITIONS

The terms used in this International Standard have the following meanings and some are illustrated in figures 1 and 2 which, however, do not purport to illustrate typical or preferred designs :

- 3.1 apparatus for gamma radiography** : An apparatus including an exposure container and accessories designed to enable radiation emitted by a sealed source to be used for industrial radiography.
- 3.2 exposure container** : A shield in the form of a container designed to allow the controlled use of gamma radiation and employing one or more gamma radiography sealed sources.
- 3.3 gamma radiography sealed source** : A sealed source in a form suitable for use in radiography, which comprises the radioactive material, usually in the form of a pellet or pellets, sealed in one or more capsules.

1) Apparatus operated by removing the sealed source from the exposure container on a handling device is not covered by this International Standard because its use is prohibited in the national regulations of some countries.

2) IAEA Safety Series No. 6, *Regulations for the safe transport of radioactive materials*; and companion document Safety Series No. 37, *Advisory material for the application of the IAEA transport regulations*, current edition.

3) At present at the stage of draft.

3.4 maximum rating : The maximum activity, expressed in becquerels followed by the value in curies in brackets, of a gamma radiography sealed source specified for a given radionuclide by the manufacturer and marked on the exposure container as specified in 7.1, and not to be exceeded if the apparatus is to conform to this International Standard.

3.5 source holder : A holding, carrying or attachment device, by means of which the gamma radiography sealed source(s) can be fixed in the exposure container or at the head of a remote control device.

3.6 remote control : A device enabling the gamma radiography sealed source(s) to be exposed by operation at a distance.

3.7 projection sheath : A flexible or rigid tube for guiding the source holder from the exposure container to the working position and comprising the necessary connections between the exposure container and the exposure head.

3.8 exposure head : A device which locates the gamma radiography sealed source in the selected working position.

3.9 secured position : Condition of the exposure container and gamma radiography sealed source when the source is fully shielded and the exposure container is rendered inoperable by locking and/or other means.

3.10 working position : Condition of the apparatus for gamma radiography when the beam is emitted for radiography.

4 CLASSIFICATION

For the purpose of this International Standard, an apparatus for gamma radiography is classified according to the mobility of the exposure container :

Class P : A portable exposure container, designed to be carried by one man alone.

Class M : A mobile but not portable exposure container, designed to be moved easily by a suitable means provided for the purpose.

Class F : A fixed installed exposure container or one with mobility restricted to the confines of a particular working area.

5 DESIGN AND CONSTRUCTION

5.1 General requirements

An apparatus for gamma radiography shall be designed with due regard for the conditions which may be encountered in use, and which may adversely affect safe operation.

Designers and manufacturers shall give particular consideration to the following :

a) the durability and resistance to corrosion of

components and their surface finishes, particularly where the functioning of controls or moving parts may be affected;

b) the need to prevent the ingress of water, mud, sand, or other foreign matter into the controls or moving parts, or the facility with which the apparatus may safely be cleaned out using, for example, a hose and water;

c) the effect of temperatures which may be encountered in use;

d) the possibly damaging effects of gamma radiation on any non-metallic components such as rubbers, plastics, jointing, sealing compounds or lubricants in close proximity to the sealed source;

e) the provision of appropriate accessories designed for the secure mounting of the exposure container or exposure head in different positions of use;

f) the interchangeability of source holders and other replacement components;

g) the provision of instructions for use, periodic inspection and maintenance.

Where depleted uranium is used as the shielding material of an exposure container, it shall be clad with a non-radioactive material of sufficient thickness to attenuate or absorb the beta radiation. If the non-radioactive cladding is liable to react with the depleted uranium at elevated temperatures, then the depleted uranium shall be given a suitable surface treatment to inhibit this effect.

5.2 Sealed sources

Sealed sources shall be designated in accordance with ISO 2919.

5.3 Exposure rate in the vicinity of the containers

An exposure container shall be made in such a way that when locked in the secured position and equipped with sealed sources corresponding to the maximum rating, the exposure rate, when tested as described in 6.2, does not exceed the limit in column (4) and one or other of the limits in columns (2) and (3) of table 1.

TABLE 1 — Exposure rate limits

1	2	3	4
Class	Maximum exposure rate, nA/kg (mR/h)		
	On external surface of container	50 mm from external surface of container	1 m from external surface of container
P	14,3 (200)	or 3,6 (50)	0,1 (2)
M	14,3 (200)	or 7,2 (100)	0,4 (5)
F	14,3 (200)	or 7,2 (100)	0,7 (10)

5.4 Safety devices

5.4.1 Locks

On all exposure containers, a series of beam emissions of source projections shall be possible only after a manual unlocking operation.

An exposure container shall be provided either with an integral lock and key or with hasps through which a separate padlock can be fitted. The lock shall be either of the safety type, i.e. lockable without the key, or an integral lock from which the key cannot be withdrawn when the container is in the working position. The lock shall retain the sealed source in the secured position and shall not, if the lock is damaged, prevent the sealed source when it is in the working position from being returned to the secured position. If a separate padlock is used, there shall be an additional device to provide a positive means of retaining the sealed source in the secured position.

5.4.2 Source position indicators

An apparatus for gamma radiography shall clearly indicate whether the sealed source is in the secured or the working position. If colours are used, green shall only indicate that the source is in the secured position and red shall indicate that the source is not in the secured position, but colours shall not be the sole means of indication.

5.4.3 System failure

A remote control system which is not manually operated shall either :

- a) be designed so that a failure of this system causes shutter closure or the return of the sealed source to the secured position, or
- b) be accompanied by a safety device, preferably manual, permitting shutter closure or the return of the sealed source to the secured position without unduly exposing personnel to radiation.

A remote control system which is manually operated shall be designed so that it is impossible for the sealed source to be withdrawn from the rear of the exposure container whilst operating, connecting or disconnecting the remote control cable.

5.4.4 Unauthorized operation

Where a remote control is incorporated, there should be provision to prevent its unauthorized operation when the operator is not in immediate attendance, for example by a removable winding handle.

5.5 Source holder security

The source holder shall be designed in such a way that it cannot release the sealed source accidentally, and shall provide it with positive retention and mechanical protection.

5.6 Handling facilities

5.6.1 Portability

A class P exposure container shall be provided with a carrying handle. A class M container shall be provided with a lifting device. Such a handle or device shall be adequate for its purpose and so secured that it cannot be accidentally parted from the container. (Such an adjunct is optional for a class F container.)

5.6.2 Mobility

The equipment provided for moving a class M exposure container shall have a turning circle of 3 m or less, and shall be fitted with an immobilizing device.

5.7 Resistance to normal conditions of service (tests to be carried out on a prototype)

The three tests referred to in 5.7.1, 5.7.2 and 5.7.3 shall be performed on the same individual class P or M apparatus in the order shown. The test referred to in 5.7.3 also applies to a class F apparatus. The tests referred to in 5.7.4 shall be performed in the order shown on each individual part of a mechanical remote control device.

5.7.1 Vibration

An exposure container of class P or M shall remain operable and still comply with the requirements of 5.3 to 5.6 after having undergone the vibration resistance test described in 6.3.

5.7.2 Shock

An exposure container of class P or M (having undergone the vibration resistance test described in 6.3) shall remain operable and still comply with the requirements of 5.3 to 5.6 after having undergone the shock resistance test described in 6.4.

5.7.3 Endurance

Source projection mechanisms of category II apparatus and source position indicating systems of categories I and II apparatus (if of class P or M, after having undergone the tests described in 6.3 and 6.4) shall remain operable and still comply with the requirements of 5.4 after having undergone the endurance test described in 6.5.

5.7.4 Kinking, crushing and tensile tests

Mechanical remote control devices after having undergone the tests described in 6.6 :

- a) shall not have suffered any damage of any kind to the link between the cable and its final linking portion with the source holder, to the control lever, or to the control mechanism linking the lever to the cable, and the sheath(s) shall not show any elongation;