INTERNATIONAL STANDARD ISO 3999

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Apparatus for gamma radiography — Specification

Appareils de radiographie gamma — Spécifications

First edition — 1977-09-01

UDC 539.166

Ref. No. ISO 3999-1977 (E)

Descriptors : industrial radiography, gamma-ray apparatus, radiation protection, gamma radiation, specifications, tests, marking, safety requirements.

Price based on 10 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3999 was developed by Technical Committee ISO/TC 85, *Nuclear energy*, and was circulated to the member bodies in January 1976.

It has been approved by the member bodies of the following countries :

Austria	Hungary	Spain
Belgium	Ireland	Sweden
Canada	Mexico	Switzerland
Czechoslovakia	Netherlands	Turkey
Finland	Poland	United Kingdom
France	Romania	
Germany	South Africa, Rep. of	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
U.S.A.

Printed in Switzerland

CONTENTS

This page intentionally left blank

Apparatus for gamma radiography — Specification

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 radiography[1].

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 materials[2] 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;

b) when laid out as shown in figure 3 the maximum torque which must be applied to the control lever to completely extend and retract the cable shall not be more than 125 % of the maximum torque which had to be applied when the device was in the geometrical arrangement before the test.

5.8 Resistance to accidental dropping (tests to be carried out on a prototype)

After a class P or M exposure container has been subjected to the free drop resistance test described in 6.7, the sealed source shall be retained within the container and the exposure rate at 1 m from its surface in any direction whatsoever shall not exceed 1 R/h when the activity of the contained source corresponds to the maximum rating.

NOTE — Conformity with the specification laid down should be checked by extrapolation from tests carried out using as weak a source of activity as possible but which is nevertheless sufficient for the results obtained to be significant taking account of the sensitivity threshold of the measuring methods and instruments.

6 TESTS

6.1 Application of the tests

Approval testing shall be carried out by a body which is authoritatively recognized as being qualified to make a full and impartial assessment.

Unless they have already fulfilled identical tests or more constraining tests under other international regulations, prototype apparatus shall be subjected to the tests shown in table 2 and still fulfil the criteria for the individual tests specified in clause 5. In addition, a prototype mechanical remote control device shall be subjected to the kinking, crushing and tensile tests shown in table 2 and still fulfil the requirements specified in 5.7.4.

TABLE 2 — **Tests**

Test			Class of apparatus		
Sub-clause No.	Evaluation	Type	P	M	F
6.2	5.3	Shielding efficiency	X	X	X
6.3	5.7.1	Vibration	X	X	–
6.4	5.7.2	Shock	X	X	–
6.5	5.7.3	Endurance	X	X	X
6.6	5.7.4	Mechanical remote control devices :			
		Kinking	X	X	X
		Crushing (unless specially protected against crushing)	X	X	X
		Tensile	X	X	–
6.7	5.8	Accidental drop	X	X	–

If the apparatus is deisgned for use in more than one class, the prototype shall be subjected to the tests of each appropriate class.

In addition to these prototype tests, a test to prove the shielding efficiency shall be carried out on all production models.

6.2 Shielding efficiency test (see 5.3)

6.2.1 *Principle*

The test consists in checking the radiation leakage from the exposure container with a view to minimizing the radiation dose to persons while the container is being transported mechanically or manually or being temporarily stored.

6.2.2 *Procedure*

Remove all accessories and carry out the test on the exposure container alone. With an appropriate radionuclide of known activity in the container, examine the entire container surface, either at the surface or at 50 mm from the surface, with X- ray film or an appropriate instrument together with further measurements at 1 m to determine that the maximum radiation levels as given in 5.3 are not exceeded at any place in any direction.

In the case of a class F container, the exposure rates in inaccessible positions need not be measured. The measurement of an exposure rate at the surface or 50 mm from the surface may be averaged over an area of 10 cm^2 and at 1 m from the surface over an area of 100 cm^2. Before measuring the levels at the surface or at 50 mm from the surface, check that the surface of the container has no radioactive contamination.

Extrapolate the exposure rates obtained to derive the exposure rates for a maximum rating of the exposure container.

NOTE — Information on radiation leakage testing is to be found in ISO 2855.

6.3 Vibration resistance test (see 5.7.1)

If a remote control device may be fitted, the exposure container shall be so equipped for this test.

6.3.1 *Principle*

The test consists in vibrating a class P or M apparatus for a given time at one of its inherent vibration frequencies with a view to checking its resistance to vibrations that occur during transport.

NOTE — When the apparatus is designed to be transported in packing, and if the inherent frequency of the apparatus and packing together is greater than the inherent frequency of the apparatus alone, the test should be carried out on the apparatus and packing together.

6.3.2 *Equipment*

Vibrating machine, equipped with a sufficiently rigid wooden platform, for example a 7- or 9-ply Gaboon (*Aucoumea klaineana*) plywood platform or equivalent.

6.3.3 *Procedure*

Place the apparatus to be checked on the rigid platform of the vibrating machine and fasten its base to the platform in such a way that it cannot move independently of the platform. This fixing, however, must not alter the inherent frequencies of the apparatus and shall, therefore, only fasten to the platform items which are rigidly integral such as the wheels of a mobile apparatus or the legs of a portable apparatus.

Determine the main inherent frequency of the container by scanning in a low amplitude frequency between 5 and 80 Hz. This inherent frequency is defined as the frequency for which the energizing force/platform speed ratio gives a value equal to or less than one-tenth of the largest value measured during the scanning. This scanning may be carried out by continuous variation or by circumspect values in the standard R 20 progression[1)].

Then vibrate the apparatus at this main inherent frequency for 8 h and with a maximum acceleration equal to 9,8 m/s^2.

If, during the initial scanning, it is noted that the container has several main inherent frequencies, energize the apparatus at each of these frequencies for 8 h with a maximum acceleration equal to 9,8 m/s^2.

If no inherent frequency is detected in the range of 5 to 80 Hz, energize the apparatus for 70 min with a maximum acceleration equal to 9,8 m/s^2, at each of the following frequencies 5, 8, 12, 20, 32 and 80 Hz [a standard R 10/2 progression[1)]].

6.4 Shock resistance test (see 5.7.2)

This test shall be made on the exposure container after the vibration test (with the remote control device fitted). The test consists in simulating the shock which an apparatus may undergo, either when carried at arm's length (horizontal shock when colliding with an obstacle) or when carried on a trolley (vertical shock when passing over an obstacle), with a view to checking its resistance.

6.4.1 *Class P exposure containers*

6.4.1.1 HORIZONTAL SHOCK

6.4.1.1.1 *Equipment*

Target, consisting of the flat vertical end face of a 50 mm diameter steel bar, 300 mm long, lying horizontally, which is fixed or welded to a rigid mass at least ten times the mass of the exposure container.

Ropes, of a type that do not cause undesirable rotation of the container around a vertical axis when it is suspended.

6.4.1.1.2 *Procedure*

Select the fragile areas on the container.

Suspend the container by means of the ropes to fixed points so placed that, when at rest, one of the fragile areas just touches the target.

Move the container from its resting position until the altitude of its centre of gravity increases by 100 mm, then let it swing in a pendulum movement against the target.

Repeat these shocks 20 times on each of the areas of container regarded as fragile.

6.4.1.2 VERTICAL SHOCK

6.4.1.2.1 *Equipment*

Rigid target (for example steel, concrete, or solid timber), of a mass at least ten times that of the apparatus and having a flat horizontal surface covered with a sheet of 7- or 9-ply Gaboon plywood or equivalent.

6.4.1.2.2 *Procedure*

From its normal carrying position, let the container fall 100 times from a height of 150 mm onto the rigid target.

The test may be carried out either manually or with the aid of a suitable mechanical device.

6.4.2 *Class M exposure containers*

Carry out the test by letting the container on its trolley or other device provided for ease of movement, moving at a speed of at least 1 m/s, drop freely down a step of height 150 mm. (The edge of the step must be such that it will not be distorted by the operation.)

The ground at the bottom of the drop shall be hard and solid (for example concrete, flagstones). If this is not the case (for example if of wood or beaten earth), cover the ground with steel sheet at least 10 mm thick.

Repeat this test 100 times.

6.5 Endurance test of the source projection mechanism and position indicating system (see 5.7.3)

This test shall be made on class F apparatus; and on class P and M apparatus after the vibration and shock tests.

6.5.1 *Principle*

The test consists in repeatedly operating the source projection mechanism and the position indicating system in order to check their resistance and that of their connecting components to fatigue.

1) See ISO 3.