International Standard ISO 2919

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

Sealed radioactive sources — Classification

Sources radioactives scellées — Classification

First edition — 1980-05-01

UDC 539.163 : 621.039.8 **Ref. No. ISO 2919-1980 (E)**

Descriptors : radiation sources, sealed sources, definitions, classification, tests, thermal tests, impact tests, pressure tests, vibration tests, punching tests, radioactivity.

Price based on 10 pages

ISO 2919-1980 (E)

Foreword

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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 2919 was developed by Technical Committee ISO/TC 85, *Nuclear energy*, and was circulated to the member bodies in September 1978.

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

Austria	Japan	Switzerland
Belgium	Mexico	Turkey
Canada	Netherlands	United Kingdom
Czechoslovakia	New Zealand	USA
Finland	Poland	USSR
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The member body of the following country expressed disapproval of the document on technical grounds :

Italy

Sealed radioactive sources — Classification

0 Introduction

The use of sealed radioactive sources has become so widespread that a standard to guide the user, manufacturer, and regulating agency is needed.

Safety is the prime consideration in establishing a standard for the use of sealed radioactive sources. Industrial users of sources have established an enviable record of safe usage as a result of careful scrutiny of the application of the source by the regulating authority, the supplier of the source and the user of the source. However, as the application of sources becomes more diversified and as regulating agencies become more numerous, a standard is needed to specify the characteristics of a source and the essential performance and safety testing methods for a particular application and, thus, maintain the record of safe usage.

In 1962, a group of experts in the USA began to consider the standard required for the safe usage of sealed radioactive sources. Their work evolved into a performance standard based on the intended use of the source, which was unique in that it did not attempt to establish design standards. It was felt that a design standard would tend to maintain the present "state-of-the-art" rather than promote innovation in the manufacture of sources to meet particular requirements. The international committee entrusted with this study has maintained this concept, and this International Standard classifies sources by performance specifications.

Annex C of this International Standard includes a list, which is not intended to be comprehensive, of typical applications of sealed radioactive sources with a suggested test schedule for each application. These schedules are minimum requirements corresponding to the applications in the broadest sense. Factors to be considered for applications in specially severe conditions are listed in 5.2 and 5.3.

This International Standard makes no attempt to classify either the design of sources and their method of construction or their calibration in terms of the radiation emitted. Radioactive materials inside a nuclear reactor and fuel elements are specifically not covered by this International Standard.

General requirements for sealed radioactive sources are given in ISO 1677.

1 Scope and field of application

This International Standard establishes a system of classification of sealed radioactive sources based on performance specifications.

It provides a set of tests by which the manufacturer of sealed radioactive sources can evaluate the safety of his products under working conditions, and by which the user of such sources can select types which suit the application he has in mind, especially where protection against the release of radioactive material, with consequent exposure to ionizing radiations, is concerned. This International Standard may also be of guidance to regulating authorities.

The tests fall into several groups including, for example, exposure to abnormally high and low temperatures, and a variety of mechanical tests. Each test can be applied in several degrees of severity. The criterion of pass or fail depends on leakage of the contents of the source. Methods of testing sources for leakage after testing are set out in ISO/TR 4826.

2 References

ISO 1677, *Sealed radioactive sources — General requirements.*

ISO/TR 4826, *Sealed radioactive sources — Leak test methods.*

3 Definitions

For the purposes of this International Standard, the following definitions apply :

3.1 capsule : Protective envelope used to prevent leakage of the radioactive material.

3.2 container : General term designating any enclosure which may surround the sealed source.

3.3 device : Any piece of equipment designated to utilize sealed source(s).

3.4 dummy sealed source : Facsimile of a radioactive sealed source the capsule of which has the same construction and is made with exactly the same materials as those of the sealed source that it represents but containing, in place of the radioactive material, a substance resembling it as closely as practical in physical and chemical properties.

3.5 leakage : Transfer of radioactive material from the sealed source to the environment.

3.6 model : Descriptive term or number to identify a specific sealed source design.

3.7 non-leachable : Term used to convey that the radioactive material in the form contained in the source is virtually insoluble in water and is not convertible into dispersible products.

3.8 prototype source : Original of a model of a sealed source which serves as a pattern for the manufacture of all sealed sources identified by the same model designation.

3.9 prototype testing : Performance testing of a new radioactive sealed source before sealed sources of such design are put into actual use.

3.10 quality control : Such tests and procedures as are necessary to establish the ability of the sealed sources to comply with the performance characteristics for that sealed source designed as defined in table 2 of this International Standard.

3.11 radiotoxicity : Of a radionuclide; the ability of a nuclide to produce injury by virtue of its emitted radiations, when incorporated in the human body.

3.12 sealed 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[1].

3.13 simulated source : Facsimile of a radioactive sealed source the capsule of which has the same construction and is made with exactly the same materials as those of the sealed source that it represents but containing, in place of the radioactive material, a substance with mechanical, physical and chemical properties as close as possible to those of the radioactive material and containing radioactive material of tracer quantity only. The tracer is in a form soluble in a solvent which does not attack the capsule and has the maximum activity compatible with its use in a glove box[2].

3.14 source holder : Mechanical support for the sealed source.

The following two terms apply to industrial radiography and gamma gauges and irradiation sources :

3.15 source in device : Sealed source which remains in a device giving mechanical protection from damage during use.

3.16 unprotected source : Sealed source which, for use, is removed from a device that would give mechanical protection from damage.

4 Classification designation

The classification of a sealed source shall be designated by the code ISO/ followed by a letter and five digits.

The letter shall be either C or E. C designates that the activity level of the sealed source does not exceed the limit established in annex B. E designates that the activity level of the sealed source exceeds the limit established in annex B.

The first digit shall be the Class number which describes the performance for temperature.

The second digit shall be the Class number which describes the performance for external pressure.

The third digit shall be the Class number which describes the performance for impact.

The fourth digit shall be the Class number which describes the performance for vibration.

The fifth digit shall be the Class number which describes the performance for puncture.

Example : a typical industrial radiography source designed for use unprotected would be designated ISO/C43515 (values are taken from annex C).

5 General considerations

5.1 Explanation of annexes and table 2

5.1.1 Classification of radionuclides according to radiotoxicity (annex A)

This annex, based on ICRP Publication 5, classifies radionuclides into four Groups according to relative radiotoxicity.

5.1.2 Activity level (annex B)

This annex establishes a maximum activity of sealed sources, for each of the four radiotoxicity Groups in annex A, below which a separate evaluation of the specific usage and design is not required.

1) This definition conforms with ISO 921, *Nuclear energy glossary*, term No. 548, except that the word "container", which is a general term, is replaced for the purpose of this International Standard by the word "capsule" (see 3.1).

2) The following activity levels are acceptable :

$^{90}Sr + ^{90}Y$ as soluble salt : 2 MBq

^{60}Co as soluble salt : 1 MBq

(1 Ci = $3{,}7 \times 10^{10}$ Bq)

Sealed sources containing more than the maximum activity shall be subject to further evaluation of the specific usage and design. The activity level of a sealed source for purposes of classification according to annex B shall be that at the time of its manufacture.

Annex B also defines the physical, chemical and geometrical forms of the radionuclide used to determine these properties; they shall be the same as the physical, chemical and geometrical forms of the radioactive material within the sealed source.

5.1.3 Sealed source performance requirements for typical usage (annex C)

Annex C is a list of some typical applications in which a sealed source or source-device will be used, together with an estimate of their minimum performance requirements.

This estimate takes into account normal usage and reasonable accidental risks but does not include exposure to fire or explosion. For sealed sources normally mounted in devices, consideration was given to the additional protection afforded the sealed source by the device when the Class number for a particular usage was assigned. Thus, for all usages shown in annex C, the Class numbers specify the tests to which the sealed source shall be subjected, except that for the category ion generators, the complete source-device combination may be tested.

Obviously, annex C does lot cover all sealed source usage situations. If the particular usage or accidental risks are likely to differ from the values suggested in the estimate, or if the sealed source usage is not shown, the specifications of the sealed source shall be considered on an individual basis by the supplier, the user, and the regulating authority. The numbers shown in annex C refer to the Class numbers used in table 2.

Attention is called to the IAEA tests for special form radioactive material.[1)] These are not of general application but may be relevant when formulating special tests.

5.1.4 Classification of sealed source performance standards (table 2)

This is a list of environmental test conditions to which a sealed source may be subjected. The tests are arranged in order of increasing severity.

The classification of each sealed source type shall be determined by actual testing of two sources (sealed, prototype, dummy or simulated) of that type for each test in table 2, or by derivation from previous tests which demonstrate that the source would pass the test if the test were performed. Different specimens may be used for each of the tests.

Compliance with the tests shall be determined by the ability of the sealed source to maintain its integrity after each test is performed.

A source with more than one encapsulation shall be deemed to have complied with a test if it can be demonstrated that at least one encapsulation has maintained its integrity after the test.

Leak test methods for sealed radioactive sources are given in ISO/TR 4826. When leak testing a simulated source, the sensitivity of the chosen method has to be adequate.

5.2 Fire, explosion and corrosion

Annex C does not consider exposure of the sealed source or the source-device to fire, explosion and corrosion. In the evaluation of sealed sources and source-device combinations, the manufacturer and user have to consider the probability of fire, explosion and corrosion and the possible results. Factors which should be considered in determining the need for actual testing are :

a) consequences of loss of activity;

b) quantity of active material contained in the sealed source;

c) radiotoxicity;

d) chemical and physical form of the material and the geometrical shape;

e) environment in which it is used; and

f) protection afforded the sealed source or source-device combination.

5.3 Radiotoxicity and solubility

Except as required by 5.2, radiotoxicity of the radionuclide shall be considered only when the activity of the sealed source exceeds the value shown in annex B. If the activity exceeds this value, the specifications of the sealed source have to be considered on an individual basis. If the activity does not exceed the values shown in annex B, annex C may be used without further consideration of either radiotoxicity or solubility.

5.4 Quality control

A quality control programme is essential and shall be operated in both the design and manufacture of sealed sources which are to be classified.

1) IAEA (International Atomic Energy Agency) Safety Series No. 6, *Regulations for the safe transport of radioactive materials*, 1973 Revised edition, paragraphs 726 to 737.

6 Procedure to establish classification and performance requirements

6.1 Establish the radiotoxicity Group from annex A.

6.2 Determine the amount of activity allowable from annex B.

6.3 If the desired quantity does not exceed the allowable quantity of annex B, an evaluation of fire, explosion, and corrosion hazard shall be made. If no significant hazard exists, the sealed source's classification may be taken directly from annex C. If a significant hazard exists, the factors listed in 5.2 shall be evaluated with particular attention to the temperature and impact requirements.

6.4 If the desired quantity exceeds the allowable quantity of annex B, an evaluation of fire, explosion and corrosion hazard and a separate evaluation of the specific sealed source usage and sealed source design shall be made.

6.5 After the required classification of the sealed source for the particular application or usage has been established, the performance standards can be obtained directly from table 2.

6.6 Alternatively, the sealed source Class can be determined from table 2 and some suitable application may be selected from annex C.

Since table 2 is arranged in order of increasing severity from Class 1 through to Class 6, sealed sources of an established classification may be used in any application having less severe specific performance requirements (classification numbers).

7 Identification

The classification designation in accordance with clause 4 shall be marked on the sealed source certificate and, where practicable, on the sealed source capsule and the sealed source container.

8 Testing procedures for table 2

8.1 General

The testing procedures given in this clause present acceptable procedures for determining performance classification numbers. All the criteria set are the minimum requirements. Procedures which can be demonstrated to be at least equivalent are also acceptable. All tests except the temperature tests shall be carried out at ambient temperature.

8.2 Temperature test[1)]

8.2.1 Equipment

The heating or cooling equipment shall have a test zone volume of at least five times the volume of the test specimen. If a gas-or oil-fired furnace is used for the temperature test, an oxidizing atmosphere shall be maintained throughout the test.

8.2.2 Procedure

All tests shall be performed in air, except that in the low-temperature test an atmosphere of carbon dioxide is a permitted alternative; this alternative permits the use of solid carbon dioxide ("dry ice"), when a temperature lower than that required will be achieved. All test sources shall be held at the maximum test temperature for a period of at least 1 h, and at the minimum test temperature for at least 20 min.

Sources to be subjected to temperatures below ambient shall be cooled to the test temperature in less than 45 min.

Sources to be subjected to temperatures above ambient shall be heated to the test temperature at least as rapidly as indicated by table 1.

Table 1 — Temperature-time relationship for temperature test

Temperature	Time
°C	min
ambient	0
80	5
180	10
400	25
600	40
800	70

For Classes 4, 5 and 6, test sources shall also be subjected to a thermal shock test. Either a second test source or the source used in the temperature test may be used. If the latter is used, it shall be evaluated for passage of the temperature test before it is subjected to the thermal shock test.

For the thermal shock test, the source shall be heated to the maximum test temperature (required for that particular Class) and held at that temperature for at least 15 min. The test source shall be transferred in 15 s or less to water at a maximum temperature of 20 °C. The water shall be flowing at a rate of at least ten times the source volume per minute, or, if the water is stationary, it shall have a volume of at least twenty times the source volume.

1) Part of this test for Class 6 is similar in principle to the heating test given in IAEA Safety Series No. 6, *Regulations for the safe transport of radioactive materials,* 1973 Revised edition, paragraph 735.

8.2.3 Evaluation

The source shall be examined visually after the test and subjected to an appropriate leak test such as that described in ISO/TR 4826.

8.3 External pressure test

8.3.1 Equipment

The pressure gauge shall have been recently calibrated and should have a pressure range at least 10 % greater than the test pressure. The vacuum gauge shall read to a pressure at least as low as 20 kPa absolute. Different test chambers may be used for the low- and high-pressure tests.

8.3.2 Procedure

Place the test source in the chamber and expose it to the test pressure for two periods of 5 min each. Return the pressure to atmospheric between the periods. Conduct the low-pressure test in air. Conduct the high pressure test in Class 6 by a hydraulic method using water as the medium in contact with the source. Preferably conduct the high-pressure test in Classes 3, 4 and 5 by the same procedure; for fear of blocking small leaks, in no case use hydraulic oil as the medium in contact with the source.[1)]

8.3.3 Evaluation

The test source shall be examined visually and subjected to an appropriate leak test such as that described in ISO/TR 4826.

8.4 Impact test[2)]

8.4.1 Equipment

8.4.1.1 Steel hammer, the upper part of which is equipped with means of attachment, and the lower part of which has a flat striking surface, 25 mm in diameter, with its edge rounded to a radius of 3 mm.

The centre of gravity of the hammer lies on the axis of the circle which defines the striking surface; this axis itself passes through the point of attachment. The mass of the hammer depends on the test Class.

8.4.1.2 Steel anvil, the mass of which is at least ten times that of the hammer. It is rigidly mounted so that it does not deflect during impact. It has a flat surface, large enough to take the whole of the source.

8.4.2 Procedure

Choose the mass of the hammer according to the Class as specified in table 2.

Adjust the drop height to 1 m, measured between the top of the source positioned on the anvil and the base of the hammer in the release position.

Position the source so that it offers its most vulnerable area to the hammer.

Drop the hammer onto the source.

8.4.3 Evaluation

Test sources shall be examined visually and subjected to an appropriate leak test such as that described in ISO/TR 4826.

8.5 Vibration test

8.5.1 Equipment

Vibrating machine capable of performing the tests specified.

8.5.2 Procedure

Fix the source securely to the platform of the vibrating machine so that at all times the source will be rigidly in contact with the platform.

For Classes 2 and 3, subject the source to three complete test cycles for each condition specified. Conduct the test by sweeping through all the frequencies in the range at a uniform rate from the minimum frequency to the maximum frequency and return to the minimum frequency in 10 min, or longer. Test each axis[3)] of the source. In addition, continue the test for 30 min at each resonance frequency found.

For Class 4, subject the source to three complete test cycles for each condition specified. Conduct the test by sweeping through all the frequencies in the range at a uniform rate from the minimum frequency to the maximum frequency and return to the minimum frequency in 30 min, or longer. Test each axis[3)] of the source. In addition, continue the test for 30 min at each resonance frequency found.

1) The source may be in water in a flexible bag sealed from the hydraulic oil in the test chamber.

2) Paragraph 748 of *Advisory material for the application of the IAEA transport regulations,* IAEA Safety Series No. 37, accepts impact test Class 4 performed with a hammer with a mass at least greater than ten times that of the source plus contents to be equivalent to the percussion and impact tests required for special form material given in IAEA Safety Series No. 6, *Regulations for the safe transport of radioactive materials,* 1973 Revised edition (paragraphs 732 and 733).

3) A maximum of three axes shall be used. A spherical source has one axis taken at random. A source with an oval or disc-type cross-section has two axes, one of revolution and one taken at random in a plane perpendicular to the axis of revolution. Other sources have three axes, taken parallel to the significant external dimensions.

8.5.3 Evaluation

Test sources shall be examined visually and subjected to an appropriate leak test such as that described in ISO/TR 4826.

8.6 Puncture test

8.6.1 Equipment

8.6.1.1 Hammer, the upper part of which is equipped with means of attachment, and the lower part of which bears a rigidly fixed pin. The characteristics of this pin are as follows :

a) hardness from 50 to 60 HRC;

b) free height 6 mm;

c) diameter 3 mm;

d) lower surface hemispherical.

The centre line of the pin is in alignment with the centre of gravity and with the point of attachment of the hammer. The mass of the hammer and pin depends on the test Class.

8.6.1.2 Hardened steel anvil, rigidly mounted and with a mass at least ten times that of the hammer. The contact surface between the source and the anvil is large enough to prevent deformation of this surface when puncture takes place. If necessary a cradle of suitable form may be interposed between the source and the anvil.

8.6.2 Procedure

Choose the mass of the hammer and pin according to the Class as required in table 2.

Adjust the drop height to 1 m, measured between the top of the source positioned on the anvil and the point of the pin in the release position.

Position the source so that it offers its most vulnerable area to the pin.

Drop the hammer onto the source.

If the source has more than one vulnerable area, carry out the test on each of them.

If the dimensions and mass of the source concerned do not permit unguided fall, lead the striker to the puncture point in a smooth vertical tube.

8.6.3 Evaluation

The test source shall be examined visually and subjected to an appropriate leak test such as that described in ISO/TR 4826.

Table 2 — Classification of sealed source performance standards

Test	Class						
	1	2	3	4	5	6	X
Temperature	No test	− 40 °C (20 min) + 80 °C (1 h)	− 40 °C (20 min) + 180 °C (1 h)	− 40 °C (20 min) + 400 °C (1 h) and thermal shock 400 °C to 20 °C	− 40 °C (20 min) + 600 °C (1 h) and thermal shock 600 °C to 20 °C	− 40 °C (20 min) + 800 °C (1 h) and thermal shock 800 °C to 20 °C	Special test
External pressure	No test	25 kPa absolute to atmospheric	25 kPa absolute to 2 MPa absolute	25 kPa absolute to 7 MPa absolute	25 kPa absolute to 70 MPa absolute	25 kPa absolute to 170 MPa absolute	Special test
Impact	No test	50 g from 1 m	200 g from 1 m	2 kg from 1 m	5 kg from 1 m	20 kg from 1 m	Special test
Vibration	No test	3 times 10 min 25 to 500 Hz at 49 m/s² (5g)[1]	3 times 10 min 25 to 50 Hz at 49 m/s² (5g)[1] and 50 to 90 Hz at 0,635 mm amplitude peak to peak and 90 to 500 Hz at 98 m/s² (10g)[1]	3 times 30 min 25 to 80 Hz at 1,5 mm amplitude peak to peak and 80 to 2 000 Hz at 196 m/s² (20g)[1]			Special test
Puncture	No test	1 g from 1 m	10 g from 1 m	50 g from 1 m	300 g from 1 m	1 kg from 1 m	Special test

1) Peak acceleration amplitude.