International Standard ISO 7205

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Radionuclide gauges — Gauges designed for permanent installation

Jauges à radioéléments — Appareils destinés à être installés à poste fixe

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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. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 7205 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Radionuclide gauges — Gauges designed for permanent installation

1 Scope and field of application

The purpose of this International Standard is to establish the following characteristics for radionuclide gauges designed for permanent installation:

a) a classification of the gauges and shielding devices;

b) technical construction and performance requirements for radiation protection when using a radioactive source;

c) control and test methods to verify the compliance of the gauges with those requirements;

d) indications to be shown on the gauges.

In addition to the construction requirements above, the gauges shall comply with existing regulations.

This International Standard does not apply to gauges which, because of their design, and due to the nature and the low activity of the sources they contain, are not subject to general rules regarding supply and possession of artificial radionuclides nor does it apply to ion generators (smoke detectors, static eliminators, etc.).

2 References

ISO 361, *Basic ionizing radiation symbol.*

ISO 921, *Nuclear energy glossary.*

ISO 1677, *Sealed radioactive sources — General.*

ISO 2919, *Sealed radioactive sources — Classification.*

ISO 3768, *Metallic coatings — Neutral salt spray test (NSS test).*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 921 and the following definitions apply.

3.1 radionuclide gauge; gauge: A control and measuring device activated by the radiation emitted by one or more sealed radioactive sources. It includes a source housing and a detector housing (or a combined source/detector housing).

3.2 source housing: Enclosure containing the radioactive source(s), a source holder and means for attenuating the radiation.

3.3 detector housing: Enclosure containing the radiation detector.

3.4 source/detector housing: Combined source/detector housing forming a rigid assembly, the two units being either coupled or contained in the same enclosure.

3.5 source holder: Device used to support and contain the sealed source.

3.6 useful beam: Radiation passing through the window, aperture, cone or other collimation device of the source housing (sometimes called "primary beam").

3.7 radionuclide gauge for permanent installation: Instrument designed to be installed in a fixed location. The detector housing and the source housing may be fixed or mobile. Mobility is limited and predetermined by the operations involved.

4 Classification of gauges

4.1 Classification on the basis of the mobility of components

Gauges are classified according to two main categories, based on their mobility:

a) Gauges having two components (source housing and detector housing) which are fixed on the structure of the industrial installation involved.

Examples: Certain level gauges, certain thickness gauges.

They are called fixed gauges on permanent installations.

b) Gauges in which at least one of the two components is movable on the structure of the industrial installation where involved.

Examples: Travelling gauges, C-frame gauges.

They are called mobile gauges on permanent installations.

4.2 Classification according to degree of collimation of the beam

Radionuclide gauges for permanent installation belong to one of the categories described in 4.2.1 and 4.2.2, depending on the degree of collimation of the beam radiated by the source housing.

The categories are illustrated in figure 1.

4.2.1 Category A: Gauges with restricted beam

Category A comprises gauges equipped with a device for collimation of radiation from the radioactive source(s), restricting one or more useful beams.

The gauges shall be designed so that radiation within the solid angles formed by the collimator and all points on the active surface of the source are intercepted by the detector housing or any other fixed absorber.

In the case of back-scatter and X-ray fluorescence gauges, interception of primary radiation and back-scattered radiation shall be possible.

4.2.1.1 Sub-category A1

Sub-category A1 comprises those gauges in which the radioactive source, when in the operating position, and the detector restrict a constant volume, i.e. either both parts of the device occupy fixed positions in relation to a fixed point on the installation or both parts constitute one rigid assembly.

Examples: Fixed-value level control and level-indication density gauges, C-frame thickness gauges, fixed thickness gauges, shielded back-scatter gauges.

4.2.1.2 Sub-category A2

Sub-category A2 comprises those gauges in which the radioactive source, when in the operating position, and the detector restrict a constant volume, the motion of both parts being mutually dependent.

Examples: Level follower or detection level control with varying set-point, thickness gauges also called "travelling gauges".

4.2.1.3 Sub-category A3

Sub-category A3 comprises those gauges in which the movements of the source housing and/or the detector housing on fixed axes are mutually dependent.

Examples: Safety alignment gauges, safety gauges on travelling cranes.

4.2.2 Category B: Gauges without restricted beam

Category B comprises gauges without a collimation device or gauges in which the collimator does not comply with the requirements for category A gauges.

In the case of back-scatter and X-ray fluorescence gauges, interception of the primary radiation and back-scattered radiation is not complete, particularly in the absence of material to be investigated.

4.2.2.1 Sub-category B1

Sub-category B1 comprises those gauges in which the radioactive source, when in the operating position, and the detector(s) occupy fixed positions in relation to one another.

Examples: Neutron moisture gauges, back-scatter gauges without associated shield.

4.2.2.2 Sub-category B2: Ejection equipment

Sub-category B2 comprises those gauges in which the detector occupies a fixed position, the source being ejected to a suitable location for measuring purposes, during the time required for measuring or control.

Examples: Compacting control devices, density gauges used in chemical plants.

4.2.2.3 Sub-category B3

Sub-category B3 comprises those gauges in which the source holder moves inside the installation, depending on parameters to be controlled and measured, and the detector moves on the outside of the installation.

Examples: Position control of a mobile part inside an installation, floats containing a source, safety alignment gauges, safety gauges on travelling cranes.

4.3 Classification as a function of safety performance

See clause 6.

5 General considerations

The source housing and the detector housing shall provide several variable functions according to the category of gauge involved, which all contribute to safety. Such functions, for each sub-category, are shown in table 2.

5.1 Radioactive source

The radioactive source(s) shall be sealed, in accordance with the requirements of ISO 2919.

5.2 Source housing

The source housing shall be designed in such a way that it will comply, for each type of gauge, with the requirements laid down in 5.2.1 to 5.2.4, in accordance with the functions shown in table 2.

5.2.1 Source holder

The fixed or mobile source holder shall

a) allow for easy positioning of the radioactive source;

b) provide means for fixing the source properly in order to prevent its loss;

c) be designed in such a way as to prevent it being dismantled by unqualified persons (for example, by placing it in an enclosure provided with a safety lock or by making it necessary to use a specially designed tool to open it) — in cases where it is impossible to eliminate access to the source holder, the device used for fastening the source in the holder shall at least be fitted with a lead safety seal;

d) allow for its proper positioning in the source housing under safe radiological and containment conditions;

e) provide, under normal service conditions, protection of the radioactive source against impacts which could damage it, if no other means are provided in the gauge for such protection;

f) ensure protection of the radioactive source against attacks of physical or chemical origin

— under normal service conditions specified by the manufacturer for gauges of sub-categories B2 and B3,

— when service conditions make it necessary for other sub-categories.

5.2.2 Restriction of useful beam

The source housing in category A gauges shall restrict the useful beam in such a way that for the maximum source-detector distance specified by the manufacturer, the solid angle formed by the centre of the source and the collimator does not extend beyond the detector or its absorbing shields.

If the source housing is designed to accommodate several collimators which form different solid angles, the manufacturer shall indicate, for each, the maximum source-detector distance.

In the case of category B gauges, it is recommended that the source holder be designed in such a way as to reduce sufficiently the dose equivalent rate, outside the useful beam, in a solid angle as required to ensure the protection of the operator.

5.2.3 Shield against ionizing radiation

The source housing of category A gauges shall ensure compliance with the dose equivalent rates corresponding to the proper gauge class (see 6.2 and table 3).

In the case of installations with mobile sources, category B gauges shall include a storage container for the source and the source holder, so that when the radioactive source is not in the measuring position, dose equivalent rates corresponding to the class of gauge involved will be met (see 6.3 and table 3).

The storage container shall form an integral part of the installation in the case of gauges of sub-categories B2 and B3; sub-category B1 gauges are not required to be equipped with an integral storage container.

If the container is constructed with materials which are combustible, oxidizible, easily fusible or volatile, these shall be enclosed in one or more sealed envelopes strong enough to retain their shielding properties under the conditions specified in 7.5.

5.2.4 Shutter for the useful beam

The source housing in category A gauges as well as the storage container in category B gauges, if any, shall be equipped with a device integral with the source housing to intercept the beam, and thus ensure, for the class in question, compliance with the dose equivalent rates laid down in table 3 (see note 2), with the shutter closed.

If this device is remote-controlled or servo-controlled, any defect in the control circuit or the servo-control circuit shall automatically close the device.

The shutters shall be classified, as indicated by the manufacturer on the operating and maintenance instructions provided on the gauge, according to one of the groups described in 5.2.4.1 to 5.2.4.3.

5.2.4.1 Group 1: Shutters for maintenance

This group comprises shutters designed to operate under certain conditions and solely during maintenance or servicing of the gauge or installation.

5.2.4.2 Group 2: Shutters used during operations (start-up/shut-down)

This group comprises shutters designed to operate on start-up and shut-down of the installation in which the gauge is incorporated.

5.2.4.3 **Group 3**: Multi-purpose shutters

This group comprises shutters which do not belong to groups 1 or 2 and which are designed to operate frequently.

5.3 Detector housing

The detector housing comprises the following elements:

a) an ionizing radiation detector; and, if any,

b) electronic or electromechanical devices closely associated with the detector;

c) absorbing shields, if necessary, and measuring instruments which form a rigid assembly with the detector housing.

5.3.1 Adjusting devices

When the dose equivalent rate in the beam exceeds 7,5 mSv/h, the detector housing shall be designed in such a way that the operator cannot place his hands or any other part of his body across the useful beam when adjusting the electronic device.

5.3.2 Protection provided by the detector housing

Subject to the category to which the gauge belongs, the detector housing shall be designed to provide, within the class under consideration, compliance with dose equivalent rates laid down in table 3.

5.4 Source/detector housing

In the case of integral devices, where the source housing and detector housing are combined, this assembly shall comply with the requirements applicable to the source housing as well as to those which apply to the detector housing.

Examples of source/detector housings are gauges with sample changer and back-scatter gauges.

5.5 Fastening devices

Devices for fastening or moving the source housing and detector housing shall be designed in such a way as to

a) facilitate positioning of the source housing or detector housing;

b) ensure permanent installation in the selected position, taking into account special environmental conditions.

The clear space between the source housing and the detector housing (in the case of thickness gauges) or the clear space between the equipment to which the gauge is fixed and the source housing and detector housing shall be kept to a strict minimum. If necessary, the source housing and the detector housing shall be designed in such a way as to accommodate additional protective devices.

5.6 Safety devices

In addition to the safety devices and requirements mentioned in the preceding sub-clauses, the source housings, category A source/detector housings and sub-category B2 gauges shall include the devices listed in 5.6.1 to 5.6.3, respectively.

5.6.1 Source housings

All source housings shall be fitted with

a) a safety device preventing use by a non-authorized person (opening the shutter, moving or ejecting the source, etc.) — in addition, this device shall be designed in such a way that failure will not block the shutter, or prevent shielding of the beam or re-entry of the source into the source holder;

b) a signal device forming an integral part of the source housing or located in its immediate vicinity, clearly showing whether the shutter is open or fully closed — the signal and warning devices shall comply with the national regulations in force governing security and safety.

5.6.2 Category A source/detector housings

The safety device may only prevent the unit being dismounted.

5.6.3 Sub-category B2 gauges

Gauges in this sub-category, equipped with an ejection device other than manual, shall be fitted with

a) a safety device allowing re-entry of the source in the storage position;

b) a safety device preventing ejection of the source in the absence of process material.

5.7 Resistance to alkaline corrosion

The source housings and their safety devices shall remain operable after the alkaline corrosion resistance test described in ISO 3768 which assesses the endurance of gauges when subjected to usual climatic environmental conditions.

6 Classification of gauges according to safety performance

6.1 General

The gauges shall be classified according to their safety performance based on the tests described in clause 7 and performed on a model or by extrapolation based on previous tests and on known physical properties of materials used.

The manufacturer shall also guarantee that all gauges manufactured will retain performance features equivalent to those of the prototypes tested for the classification of the gauges.

For each category and sub-category (see 4.2), gauges shall be classified according to their performance with respect to radiological safety, based on the following criteria:

a) external radiation level;

b) suitability under normal service conditions, i.e.
- maximum and minimum service temperatures,
- endurance;

c) resistance under certain adverse conditions, e.g. fire;

d) when conditions of use so dictate, additional criteria may be defined by common agreement between the user and the manufacturer, such as
- corrosion by acids and alkalis,
- vibration and shock,
- shear,
- pressure,
- explosion,
- immersion,
- climatic test.

Typical test values for each class are indicated in tables 3 and 4.

6.2 Dose equivalent rate in the vicinity of gauges
(measurements to be carried out on prototypes)

The dose equivalent rate in the vicinity of the gauges shall be measured under the conditions described in 7.2, the gauge being equipped with a radioactive source of maximum activity specified by the manufacturer, and installed according to the latter's instructions specified in the user's manual (see table 5) for both of the following cases:

a) gauge not in use, with the radioactive source in protected position;

b) gauge in operation.

6.3 Suitability under normal service conditions
(tests to be carried out on prototypes)

6.3.1 If the source housing is a separate and independent unit, the tests shall be made on the source housing alone, connected to its control and safety devices, if any. Each test may be carried out on a different unit taken from a lot of identical samples.

6.3.2 Shutters and devices for ejection of the radioactive source shall be operable

- at the maximum and minimum temperatures indicated in table 3;

- at the end of the thermal, vibration and endurance tests.

6.3.3 At the end of the tests outlined above, safety devices shall remain operable and the information legible.

6.4 Resistance under adverse conditions (fire)
(tests to be carried out on prototypes)

Compliance with the requirements of resistance tests under adverse conditions is determined by the ability of the gauge to maintain acceptable radiological safety [no more than 10 mSv/h (1 rem/h) at a distance of 1 m from all walls and in all directions].

However, it is not necessary for the gauges to remain in an operational mode after these tests. The criteria for acceptance, after the tests, are as follows:

a) absence of any dispersed radioactive matter;

b) retention of the radioactive source by the source housing;

c) maintenance of a dose equivalent rate lower than 10 mSv/h (1 rem/h) at a distance of 1 m in any direction.

This evaluation can be performed with a simulated source. The search for contamination should be performed on the external walls of the source housing and it shall not exceed 2 kBq (50 nCi).

At the end of this test, if the dose equivalent rate of 10 mSv/h at a distance of 1 m is a requirement, it shall be possible to place the manual shielding device (category A) and the ejection device (category B) in a protected position.

7 Test methods

7.1 General

After the tests described in 7.3 to 7.5, results shall be evaluated. The evaluation shall include, as applicable,

a) evaluation of operation: ten cycles as specified for the endurance test (see 7.4);

b) evaluation of legibility: permanent marking (see 8.2) shall remain legible after the tests;

c) evaluation of contamination: contamination on the surface of the device and of the test enclosure shall not be greater than 2 kBq (50 nCi);

d) evaluation of dose equivalent rate (see 7.3 to 7.5).

The dose equivalent rate at 5 cm when the source is in "protected position" shall not exceed ten times the initial value.

7.2 Evaluation of dose equivalent rates

7.2.1 Purpose

The purpose of the evaluation of dose equivalent rates is to determine

a) at 5 cm from the wall of the external surfaces of the units, the dose equivalent rate on the skin; this rate is deter-

mined with a detector having a wall equivalent to 7 mg/cm^2;

b) at 1 m from the external surfaces of the units, the dose equivalent rate in depth; this rate is determined with a detector having a wall equivalent to 1 000 mg/cm^2;

c) at intermediary distances, if needed, the dose equivalent rate with a crystalline lens; this rate is determined with a detector having a wall equivalent to 300 mg/cm^2.

For measurement at 5 cm from external surfaces, the centre of the sensitive volume of the detector shall be situated at 5 cm from these surfaces and the rate recorded shall be the mean reading for a 10 cm^2 surface.

For measurement at 1 m from external surfaces, the rate recorded shall be the mean reading for a 100 cm^2 surface.

7.2.2 Gauge loading conditions

The dose equivalent rates shall be evaluated for each possible activity or for the maximum activity of each nuclide specified by the manufacturer. These evaluations shall be made using properly calibrated methods and instruments which are suitable for the radiation levels of the gauges.

If a gauge may be used with more than one radioactive source, evaluation shall be made with all sources in place. If a source of neutrons is used, the dose equivalent rate shall be the sum of the dose equivalent rate from the fluence of the neutrons and from the associated ionizing radiation dose rate.

7.2.3 Measuring positions

Measurement shall be made so as to take into account the total area of two imaginary surfaces situated at 5 cm and 1 m from the external surfaces of the source and detector housings (see table 3).

However, the following remarks shall be taken into consideration:

a) In the case of measurements made with a "closed shutter"

— If the distance measured along the axis of the useful beam of radiation between the source housing and the detector housing is less than or equal to 10 cm, no measurement shall be made between the two units.

— If the distance measured along the axis of the useful beam of radiation between the source housing and the detector housing is greater than 10 cm, measurements between the two units should be made with the surface to be measured simplified as shown in figure 2.

b) In the case of measurements with the shutter in the "open position"

— No measurement shall be made in the air gap between the source housing and the detector housing.

The number of measuring points is not determined; however, measurements shall be made at least on the leakage paths where the readings are the highest.

No reading shall be greater than those indicated in table 3 for the class involved.

7.3 Temperature variation test

7.3.1 Test equipment

The test shall be performed in a climatic chamber where the minimum and maximum temperatures in table 3 may be reached. Measures shall be taken to monitor, during the test, the performance of the safety devices installed in the source housing.

7.3.2 Procedure

The time required for the source housing unit to reach the test chamber temperature shall be determined by experiment or by computation.

In this sub-clause, the time required to reach stability is referred to as the "stabilization time".

Measure and record the radiation emitted by the source housing (source in protected position) at the beginning of the test.

Relative humidity in the climatic chamber shall be (65 ± 10)% at the beginning of the test cycle (with a room temperature of 20 ± 1 °C).

Lower the temperature in the climatic chamber to the lowest value given in table 3 and maintain this temperature for the stabilization time plus 1 h.

After this, check the operation of safety devices.

Then raise the temperature in the climatic chamber to room temperature (i.e. 20 ± 1 °C). After the stabilization time plus 1 h, check the safety devices again.

Raise the temperature in the climatic chamber to the maximum value specified in table 3 and maintain this temperature for the stabilization time plus 1 h.

After this, check the safety devices.

Bring the temperature in the climatic chamber down to room temperature (i.e. 20 ± 1 °C). After the stabilization time plus 1 h, check the operation of the safety devices. At this point, remove the source housing from the climatic chamber and examine visually for defects.

Measure the dose equivalent rates emitted by the source housing with a "closed shutter" mode, record the values and compare them with those observed prior to the test. The reading shall not exceed one and a half times the initial reading.

The integrity of the source shall be checked (see ISO 1677).

7.4 Endurance test

7.4.1 Purpose

The purpose of the endurance test is to verify the resistance to wear of ejection devices, shutters and position-signal devices (see 6.3.3).

7.4.2 Procedure

Tables 3 and 4 indicate for the category and group of gauge, the number of cycles to be performed.

For manual shielding control devices, the test (opening and closing the shutter, moving the source holder from its storage position to its extreme operating position) may be carried out manually or by means of an automatic device. The drive mechanism is then adjusted to exert, in each direction, the power specified by the manufacturer for normal operation.

In the case of remote- or servo-controlled devices, the endurance tests shall be carried out in the following order:

— opening and closing cycles of the shutter;

— ejection and repositioning cycles of the source holder.

7.5 Fire resistance

7.5.1 Test equipment

The furnace used for these tests shall have sufficient heating capacity to heat the air near the source housing under test to the experimental temperatures specified in table 1.

The test shall be carried out with the source in "non-operating position".

Table 1

Time min	Temperature °C
0	Room temperature
5	556
10	659
15	718
30	821
60	925
90	986
120	1 029
180	1 090
240	1 133
360	1 193

NOTE — This table corresponds to the values on the temperature rise curve.

7.5.2 Procedure

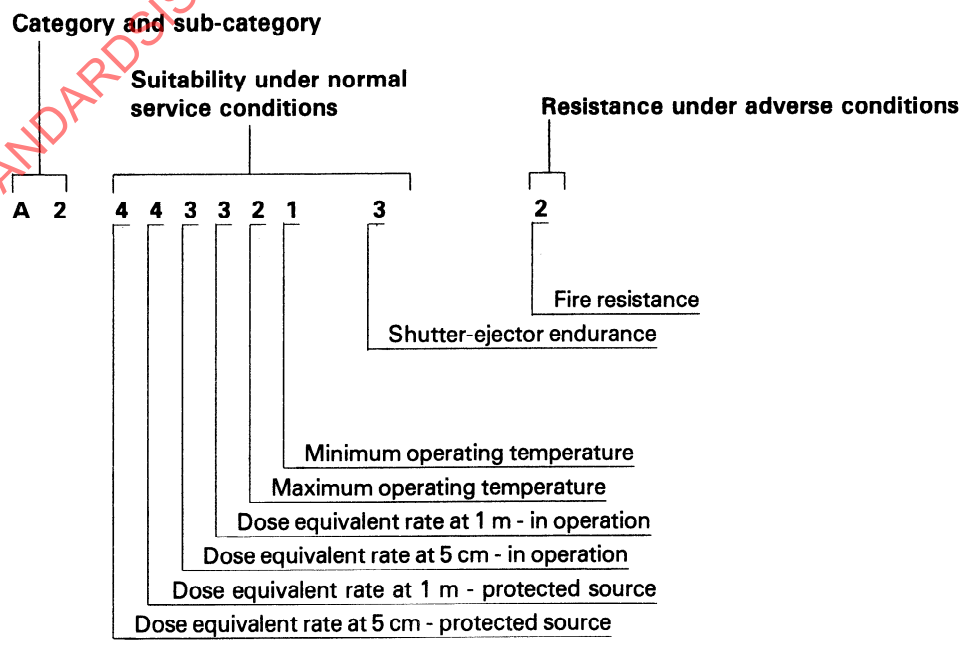
All tests shall be carried out in air. The temperature of the device being tested shall be determined by means of thermocouples evenly distributed near all exterior parts of the device.

The fire resistance test shall be carried out until the time and temperature requirements specified are met.

8 Gauge codes and markings

8.1 Code

Each gauge shall bear a code indicating its category, sub-category and performance class (see table 3), in the order given below.



8.2 Permanent markings

The following information shall be clearly marked on the source housing or source/detector housing :

a) the type and serial number of the gauge;

b) the block diagram of ionizing radiation (see ISO 361);

c) the reference to this International Standard as well as the identification code;

d) in addition, the source(s) contained in the gauge shall be identified by means of the following markings:

1) the chemical symbols and mass numbers of the nuclides,

2) the activities of source(s) when operational; this marking shall be engraved, stamped or reproduced in any other manner, in such a way as to

— remain legible throughout the working life of the gauge,

— withstand the tests described in 5.7 and 7.5 and remain legible after their completion.

The marking plate shall also bear the maximum and minimum activities of the nuclides used for normal operation of the installation under test. This marking shall remain legible for the entire period of use of the nuclides.

9 Accompanying documents

9.1 General

All radionuclide gauges shall be supplied with documents containing sufficient information for the user, as follows:

a) a description of the gauge, operating principles, technical features, in particular, the code, the nature of nuclides that may be used and, for each nuclide, the maximum activity;

b) the installation and operating conditions to be met in order to reduce radiation diffused by the installation to a minimum;

c) normal maintenance and repair which may be performed by the user, including maintenance of identification plates;

d) warnings in order to prevent inadvertent intervention, especially when handling the source holder, shutters and safety devices;

e) instructions in order to limit the effects of any incident involving the source housing.

9.2 Individual labels

Each radionuclide gauge shall have an individual label giving its characteristics as well as the identification numbers of the source(s) which have been incorporated therein, specifying for each source the maximum distance between the surface of the gauge and the dose equivalent rate points at 2,5 and 7,5 µSv/h (0,25 and 0,75 mrem/h) as well as isodose curves for 2,5 and 7,5 µSv/h.

Table 2 — Source housing and detector housing functions

Functions			Sub-category of gauge (see 4.2) A1	A2	A3	B1	B2	B3
Source housing	Source holder	Fastening of source	+	+	+	+		
		Control of motion of source					+	+
	Restriction of radiation beam		+	+	+	0	0	0
	Source protection	Mechanical	+	+	+	+	+	+
		Physico-chemical attack	If necessary	If necessary	If necessary	If necessary	+	+
	Protection against radiation	Gauge not in operation (while source or shutter is being moved)	+	+	+	0	+	+
		Gauge in operation (outside useful beam)	+	+	+	0	0	0
Detector housing	Protection against radiation	Gauge in operation (within useful beam)	+	+	0	0	0	0

NOTE — The figure "0" indicates that protection shall be provided by installation requirements.

Table 3 — Gauge classification according to safety performance requirements

Test \ Class	0	1	2	3	4	5[1]
Dose equivalent rate[2]						
at 5 cm	> 1 mSv/h (100 mrem/h)	> 0,5 mSv/h (50 mrem/h) and ⩽ 1 mSv/h (100 mrem/h)	> 0,05 mSv/h (5 mrem/h) and ⩽ 0,5 mSv/h (50 mrem/h)	> 7,5 µSv/h (0,75 mrem/h) and ⩽ 0,05 mSv/h (5 mrem/h)	⩽ 7,5 µSv/h (0,75 mrem/h)	Special
at 1 m	> 0,1 mSv/h (10 mrem/h)	> 25 µSv/h (2,5 mrem/h) and ⩽ 0,1 mSv/h (10 mrem/h)	> 7,5 µSv/h (0,75 mrem/h) and ⩽ 25 µSv/h (2,5 mrem/h)	> 2,5 µSv/h (0,25 mrem/h) and ⩽ 7,5 µSv/h (0,75 mrem/h)	⩽ 2,5 µSv/h (0,25 mrem/h)	Special
Suitability under normal service conditions						
maximum temperature	50 °C	100 °C	150 °C	200 °C	400 °C	Special
minimum temperature	10 °C	0 °C	− 10 °C	− 20 °C	− 40 °C	Special
endurance according to shutter/ejector group	Number of cycles specified in table 4		Twice the number of cycles specified in table 4	Five times the number of cycles specified in table 4	Eight times the number of cycles specified in table 4	Special
Resistance under adverse conditions						
Fire[3]	20 min (up to approximately 780 °C)		1 h (up to approximately 945 °C)	2 h (up to approximately 1 050 °C)	4 h (up to approximately 1 150 °C)	Special

1) Class 5 tests are based on specific hazards of an installation, as defined in the contract between the user and the manufacturer. However, these tests shall in no case be less stringent than tests specified for class 4.

2) Each gauge is classified according to this table, for dose equivalent rates measured at 5 cm and 1 m with source in "protected position" and for the same parameters with source in "operating position".

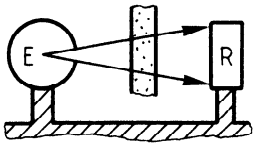
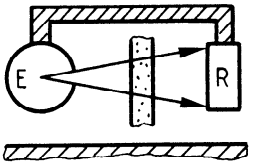
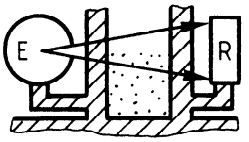
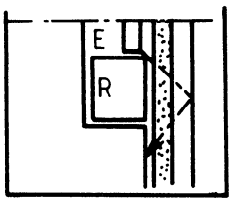
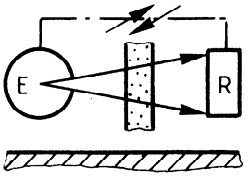
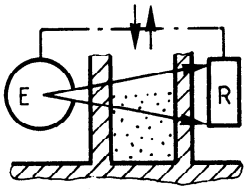
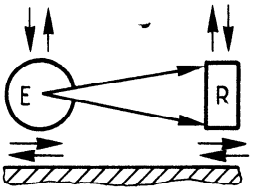
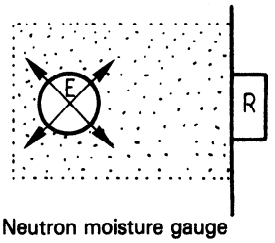
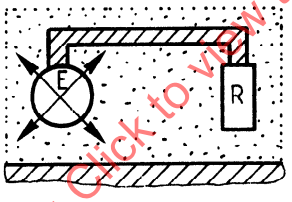
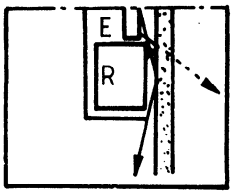
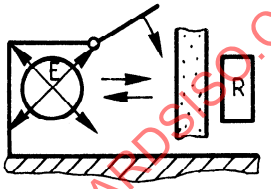
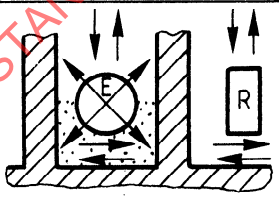
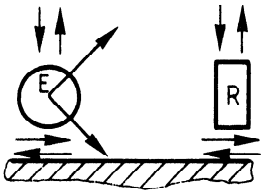
3) Not applicable if radioactive source is a gas.

Table 4 — Number of operating cycles for endurance test

Category	Sub-category	Gauge features		Number of cycles		
				Group 1	Group 2	Group 3
A	A1	Fixed source	Manually controlled shutter	100	3 000	—
			Remote- or servo-controlled shutter	—	3 000	25 000
	A2	Mobile source within source housing	Manually controlled shutter	100	3 000	—
			Remote- or servo-controlled shutter	—	3 000	25 000
B	B2	Ejection equipment	Manually-controlled ejector	—	7 500	—
			Ejector, other than manual or servo-controlled	—	15 000	25 000
	B3		Device for controlling motion and direction of source holder, if provided	—	2 500	—

Table 5 — Standard installation requirements for measurement of dose equivalent rates

Instrument type	Installation and measurement requirements
Density gauge (see figure 3) photon-neutron	Mounted on a pipe, container or equivalent Measurement for all source/detector housings air gap dimensions indicated or for the most unfavourable dimension No product inside pipe
Level gauge (see figure 4)	Source housing and detector housing mounted on test equivalent consisting of steel sheet having a thickness of 13 mm Measurement for all source/detector housings air gap dimensions indicated or for the most unfavourable dimension No product substitute in source/detector housings air gap
Other transmission gauges (see figure 2) photon-electron-neutron (thickness or parameter related thereto)	No product in source/detector housings air gap Measurement for all source/detector housings air gap dimensions indicated or for the most unfavourable dimension
Back-scatter or fluorescence gauges	
a) Product under investigation supported (cylinders, moving belts) (see figure 5)	Mounted at nominal distance specified by the manufacturer Support equivalent for product under investigation shall have sufficient thickness to absorb all electrons or 99 % of photons in primary beam Measurement for all cylinder diameters or for the most unfavourable diameter
b) Product under investigation unsupported (see figure 6)	Mounted at nominal distance specified by product manufacturer for most unfavourable product envisaged
c) Neutron gauges mounted on container (see figure 7)	Mounted on standard diffuser consisting of a steel screen having a thickness of 6 mm and a polyethelene screen having a thickness of 20 mm

A	A1	 Fixed thickness gauge	 C-frame thickness gauge	 Fixed-value level control and level indication density gauge	 Shielded back-scatter gauge
	A2	 Travelling gauge	 Level follower or detection level control with varying set-point		
	A3	 Safety alignment gauge, safety gauge on travelling cranes			
B	B1	 Neutron moisture gauge	 Neutron moisture gauge		 Back-scatter gauge without associated shield
	B2	 Compacting control device, density gauge			
	B3	 Float containing a source, position control of a mobile part	 Safety alignment gauge, safety gauge on travelling cranes		

Key

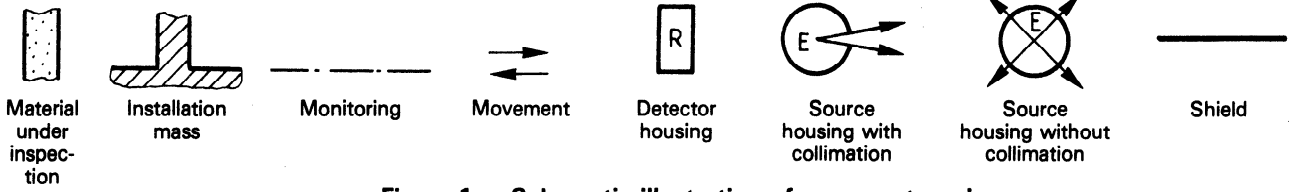


Figure 1 — Schematic illustration of gauge categories

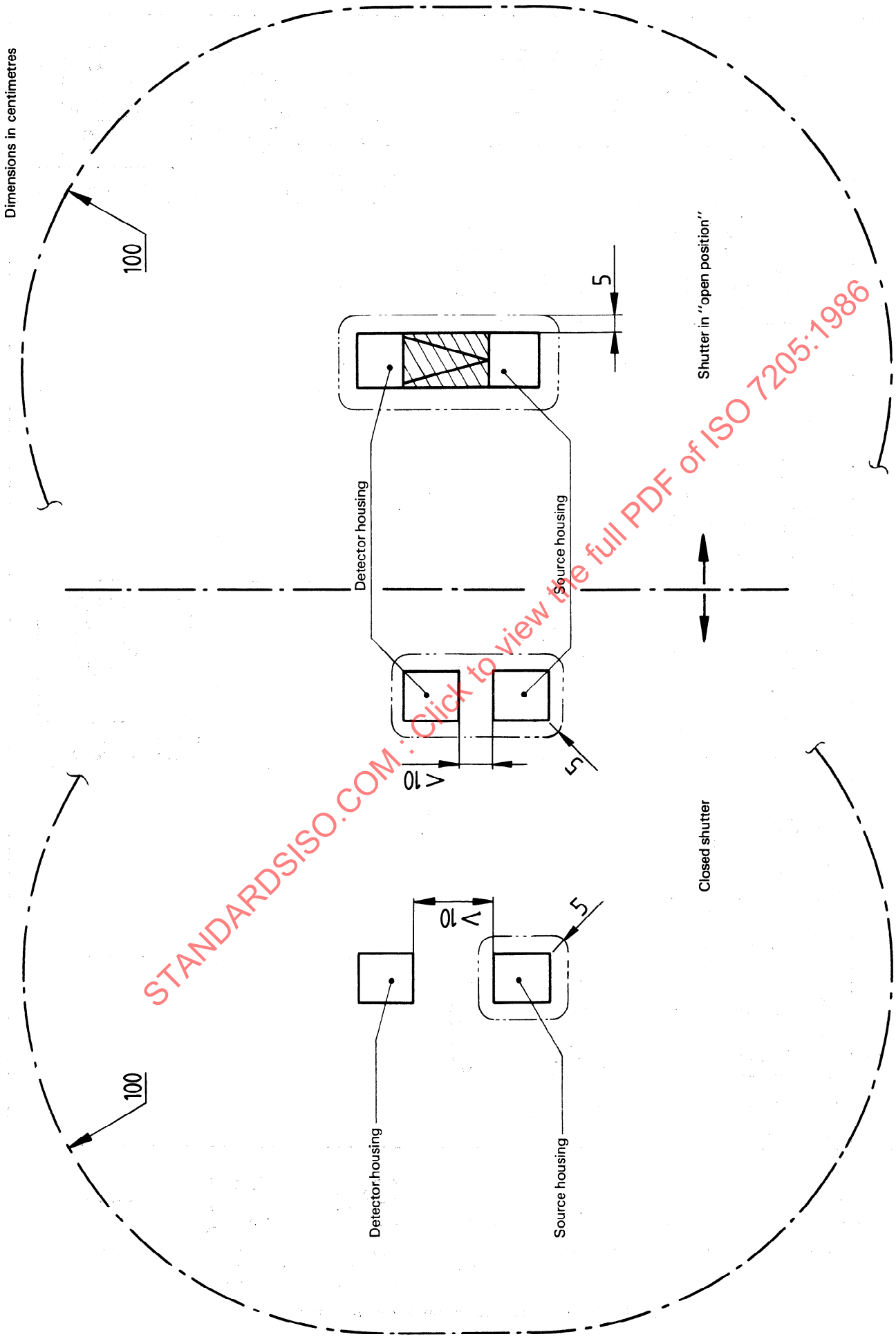


Figure 2 — Isodistance contours