INTERNATIONAL STANDARD

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Radioluminescence for time measurement instruments — Specifications

Radioluminescence pour les instruments horaires — Spécifications

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

International Standard ISO 3157 was prepared by Technical Committee ISO/TC 114, *Horology*, Sub-Committee SC 5, *Luminescence*.

This second edition cancels and replaces the first edition (ISO 3157:1975), which has been technically revised.

Annex A of this International Standard is for information only.

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Radioluminescence for time measurement instruments — Specifications

1 Scope

This International Standard specifies requirements for the optical, mechanical and radioactive characteristics of the radioluminescent deposits fixed on time measurement instruments, together with the test methods relating to them.

Clause 3 applies to all time measurement instruments which include components (hands, dials, bezels, etc.) bearing radioluminescent deposits.

Clause 4 applies to the deposits themselves, whether they are fixed on the time measurement instruments in question, or on special supports.

2 Definitions

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

2.1 radioluminescence: Luminescence caused by the radiation of a radionuclide within certain crystalline powders (ZnS, Zn_2SiO_4, etc.).

2.2 radioluminescent deposit: A radioluminescent substance in powder form mixed with a binder and fixed on a support.

2.3 special time measurement instruments: Instruments designed for uses which require considerable luminosity. Because of this, the quantity of radioactive substance used is greater.

NOTE 1 In this International Standard, the terms in italics have the same meaning as in current international documents. It is specified that the *luminous intensities* are, until further notice, defined on the basis of $V(\lambda)$, the *photopic* luminous efficiency function defining the mean eye for *photometry*. Certain terms must, however, be specially defined.

3 Specifications and test methods for time measurement instruments

3.1 General

This clause gives specifications for time measurement instruments bearing radioluminescent deposits, as well as the test methods which shall be used.

3.2 Legibility

3.2.1 For watches using radioluminescent substances, the following quality criteria apply.

a) At least four hour markings shall be used. It is permissible to use only three, however, when the instrument includes an aperture.

b) The 12 shall be differentiated from the other markings.

c) The hour-hand shall be differentiated from the minute-hand.

d) If only four markings are used, the total *luminous intensity*, i.e. that of the whole (hands + markings) shall be at least 25 ncd. However, in the case of three markings, permitted above, this lower limit is reduced to 22 ncd.

e) If more than four markings are used, the above threshold is increased by 3 ncd per additional marking.

f) The pair of hands, taken in isolation, shall have a *luminous intensity* of 10 ncd or more.

3.2.2 For time measurement instruments not worn on the person, the minimum values of the *luminous intensities* above are doubled; points a), b) and c) of 3.2.1 also remain valid.

These specifications apply within the framework of present techniques, but they do not constitute a limitation on the development of new techniques based, for example, on the use of non-luminescent markings on dials whose whole surface is luminescent.

3.3 Nature of the radionuclides used

3.3.1 Only the use of the following radionuclides is authorized:

Tritium	(^{3}H)	For marking: **T**
Promethium	(^{147}Pm)	For marking: **Pm**

3.3.2 The use of different radionuclides on the same time measurement instrument is prohibited.

NOTE 2 Attention is drawn to the fact that certain national regulations may prohibit or limit the use of one of the radionuclides listed in 3.3.1.

3.4 Total radioactivity of the instruments

Tables 1 to 3 give, for each category of instrument and type of radionuclide, the maximum values authorized for the mean radioactivity of the instruments of a lot, according to document No. 23 of the IAEA Safety Series, and the radioactivity of an instrument considered individually.

Table 1 — Time measurement instruments: Worn

Radionuclide	Maximum permitted mean activity of a lot (per instrument)	Maximum permitted activity of an isolated instrument
^{3}H	185 MBq (5 mCi)	277 MBq (7,5 mCi)
^{147}Pm	3,7 MBq (0,1 mCi)	5,5 MBq (0,15 mCi)

Table 2 — Time measurement instruments: Not worn or carried on the person

Radionuclide	Maximum permitted mean activity of a lot (per instrument)	Maximum permitted activity of an isolated instrument
^{3}H	277 MBq (7,5 mCi)	370 MBq (10 mCi)
^{147}Pm	5,5 MBq (0,15 mCi)	7,4 MBq (0,2 mCi)

Table 3 — Special time measurement instruments

Radionuclide	Maximum permitted activity of an isolated instrument
^{3}H	925 MBq (25 mCi)
^{147}Pm	18,5 MBq (0,5 mCi)

3.5 Protection against radioactivity

The "envelope" of the time measurement instrument (case, glass and protective varnish) shall be so constituted that the user is protected against any direct contact with the components treated with radioluminescent material, and that the low-energy β-radiations are sufficiently absorbed.

In any case, any deposit of radioluminescent material shall be protected by a thickness of transparent non-radioactive material equal to 50 mg/cm^2 or more.

The mechanical strength of this protection shall be sufficient to bear the stresses encountered under normal conditions of use and, as far as is reasonably practicable, during possible accidents.

3.6 Checking the radioactivity

The radioactivity may be checked, in relation to the requirements specified in 3.4, on the time measurement instrument fitted with its normal protection (glass). A method based on photometric measurement is authorized. If the measurement of the *Bremsstrahlung* is used, account shall be taken of the attenuation due to the glass and to the deposit itself. The thicknesses of the glass and the deposit are either measured or estimated by convention at 50 mg/cm^2 each. This is without prejudice to the requirements specified in 3.5.

When uncertainty resulting from the above-mentioned methods of checking makes it impossible to guarantee that the requirements specified in 3.4 are complied with, a destructive method shall be used to measure the activity. Such destructive methods shall consist in isolating the radionuclide from the other constituents of the luminescent substance, or from the deposit, and converting it into a form suitable for as accurate a measurement as possible to be made.

NOTE 3 For example, for tritiated substances, a suitable method consists in destruction of the luminescent deposit by combustion, collection of the liberated water and measurement of its activity with a liquid scintillator.

3.7 Marking

The marking specified below is obligatory only for special time measurement instruments. It is intended for the information of the horologist as well as the user.

It shall be effected, legibly and indelibly, on the dial of the instrument.

It shall comprise one of the two following indications:

T 25 for deposits activated by tritium;

Pm 0,5 for deposits activated by promethium.

These indications give the value, in millicuries, of the maximum authorized radioactivity.

For the other time measurement instruments, the marking can be made on the dial by the letters T or Pm.

3.8 Checking the marking

The marking shall be checked by visual inspection.

4 Specifications and test methods for radioluminescent deposits

4.1 General

This clause gives specifications for the radioluminescent deposits, as well as the test methods which shall be used.

The specifications relating to the deposits can be checked, unless special restrictions are indicated,

a) on the finished instruments,

b) on the dials (see clause 1 and 4.6), or

c) on a sample placed on a standard support made of stainless steel having a *reflectivity* between 0,2 and 0,3, comprising a circular coupelle containing a circular cup with a surface area of 1 cm^2, intended to hold 50 mg of powder (see figure 1);

d) on standard hands (see clause 1 and 4.6);

e) on the rectangular support defined for the checking of the colours (see 4.2.2).

Dimensions in millimetres

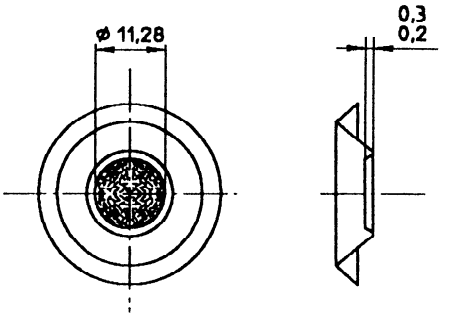

Figure 1 — Detail of a standard support for radioluminescent material

4.2 Colours

4.2.1 Standardized colours

The standardized colours are the following:

C1 — white

C3 — yellow

C5 — greenish yellow

C7 — green

C9 — blue/green

This list is not restrictive and, on agreement between the manufacturer and the user, other colours may be used.

4.2.2 Checking the colours

The colours of the deposits shall be checked by visual examination, in daylight, without sun, on samples as defined in 4.1 c).

The colours shall be compared with those of reference standards consisting of 50 mg of non-activated luminescent powder deposited on a surface of 1 cm^2 at one end of a standard support of the design shown in figure 2, made of stainless steel having a *reflectivity* between 0,2 and 0,3. The reference standards shall be stored in the dark.

NOTE 4 The standards may be supplied on request by the Secretariat of ISO/TC 114, Bureau des normes de l'industrie horlogère suisse, Crêt-Taconnet 32, CH-2002 Neuchâtel.

Figure 2 — Standard support for colour deposits

4.3 Specific luminous intensity

The quality of the deposits is characterized by their *luminous intensity* per unit mass of powder when they are examined in layers of 50 mg of powder per square centimetre, on a support having a *reflectivity* between 0,2 and 0,3.

4.3.1 Allocation of quality classes

It is recommended that the specific *luminous intensities* expressed in *microcandelas* per gram of powder (μcd/g), be included between the intervals given in table 4.

The minimum values indicated are imperative, while the maximum values are only given as an indication.

Table 4 — Specific luminous intensity

Values in microcandelas per gram

Class	Minimum value	Maximum value
L1	2,5	3,15
L2	4	5
L3	6,3	8
L4	10	12,5
L5	16	20
L6	25	31,5
L7	40	50
L8	63	80

NOTES

1 If necessary, supplementary classes 9, 10, etc. may be introduced by using the R5 series of preferred numbers.

2 The short designation of a radioluminescent substance defining its colour and quality is, for example, T-ISO-C5-L7.

4.3.2 Checking of the specific luminous intensity

The deposit shall be applied on a standard support as specified in 4.1 c).

The *luminous intensity* shall be checked after the luminescent deposit has been kept in darkness for at least 3 h.

The *luminous intensity* is measured with a photometer equipped with photomultiplier tube showing a response curve corresponding to $V(\lambda)$, the photopic luminous efficiency function (see note 1), or any other equipment assuring an equivalent precision.

The characteristics of the reference standards used for this measurement and the radioluminescent deposits shall be similar. They shall present a satisfactory stability and be periodically checked by an official organization.

The *luminous intensity* shall be evaluated in relation to the mass of the powder in the deposit, in conformity with the specifications given in 4.3.1.

NOTE 5 ISO carbon-14 reference standards are checked periodically and may be supplied on request by the Secretariat of ISO/TC 114.

4.4 Resistance to ageing

4.4.1 Nature of the test

It is considered that simultaneous exposure to heat, humidity and activating light constitutes a test of accelerated ageing which simulates validly the conditions of real ageing.

4.4.2 Procedure

Heat a crystallizer (a glass container in the form of a cylinder with a flat bottom) containing water to a temperature of 45 °C to 50 °C. When this temperature is obtained, introduce the deposit on a support which must not be immersed. Cover the crystallizer with a filter transparent to ultraviolet radiation having a wavelength greater than 300 nm (for example, a Schott WG 280 filter[1]).

Expose the deposit to the radiation of a high-pressure mercury lamp (for example, OSRAM, Ultra-Vitalux of 300 W[1]). The standard duration of exposure is 3 h at a distance of 300 mm for a 300 W lamp. (As a reference value, the standard ultraviolet irradiance at 300 mm is 3 mW/cm^2.) The actual duration of exposure shall be adapted to the irradiance produced by the lamp used.

No condensation shall be observed under the filter.

4.4.3 Estimation of the resistance to ageing

The *luminous intensity* of the deposit shall be measured before and after the test. The loss in *luminous intensity*, measured at the latest 5 h after the end of the irradiation, shall be less than 10 %.

NOTE 6 A test conducted for more than 3 h allows estimation of the resistance to "greying" (deterioration of the colour of the deposit).

1) Schott WG 280 and OSRAM Ultra-Vitalux are examples of suitable commercially available products. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of the products named. Equivalent products may be used if they can be shown to lead to the same results.