International Standard 1757

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Personal photographic dosemeters

Dosimètres photographiques personnels

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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.

International Standard ISO 1757 was developed by Technical Committee ISO/TC 85, *Nuclear energy,* and was circulated to the member bodies in February 1978.

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

Australia	Germany, F.R.	South Africa, Rep. of
Austria	Ireland	Sweden
Belgium	Italy	Switzerland
Brazil	Japan	Turkey
Canada	Mexico	United Kingdom
Czechoslovakia	New Zealand	USA
Finland	Poland	USSR
France	Romania	Yugoslavia

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

Hungary
Netherlands

This International Standard cancels and replaces ISO Recommendation R 1757-1971, of which it constitutes a technical revision.

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Personal photographic dosemeters

1 Scope and field of application

This International Standard specifies the classification, characteristics and test procedures for personal photographic dosemeters[1] used to determine

— absorbed doses due to X or gamma radiations with an energy less than 3 MeV;

— absorbed doses due to beta radiations with maximum energy from 0,6 MeV to 3 MeV, whether or not this radiation be accompanied by X, gamma or bremsstrahlung photon radiation.

This International Standard is particularly applicable to dosemeters intended to be carried on the chest or wrist.

It is also applicable to dosemeters carried on the fingers and used in the presence of these types of radiation. However, certain specifications should be adapted or supplemented according to the special requirements for these dosemeters.

Dosemeters equipped with fluorescent intensifying screens will be the subject of additional specifications, particularly regarding reciprocity defects.

Some requirements of this International Standard may also be applicable to photographic dosemeters for thermal neutrons, whether or not they are mixed with X or gamma radiation. A supplement will specify the requirements which have to be adapted or supplemented to satisfy the special requirements for these dosemeters.

This International Standard is not applicable without restriction

— to dosemeters used to determine the absorbed doses due to sources of pulsed radiation (for example, accelerators), or

— to dosemeters used in significant fields of fast neutrons.[2]

It is not applicable to nuclear track emulsions.

NOTE — The term "dosemeter" is used in the text of this International Standard to mean "personal photographic dosemeter" in every instance that the complete instrument, as it may be used in practice, is concerned and the word "dose" is used instead of "absorbed dose" for purposes of simplification.

2 References

ISO 5, *Photography — Determination of diffuse transmission density.*

ISO 4037, *X and γ reference radiations for calibrating dosemeters and dose ratemeters for determining their response as a function of photon energy.*

3 Definitions

3.1 personal photographic dosemeter : Dosemeter comprising

a) one or more photographic emulsions which, after measurement of the optical density and interpretation of the result, to assess the dose on that part of the body where the dosemeter is worn;

b) filters;

c) protective wrapping.

3.2 filter : The part of the dosemeter that modifies the effect of various radiations on the emulsion, enabling on the one hand an assessment to be made of the dose and (in many cases) the energy of the radiation, and on the other hand a differentiation to be made between the various types of radiation.

3.3 *kerma in air* : Quotient of the sum of the initial energies of all the charged particles liberated by indirectly ionising particles in a volume element of air by the mass of air contained in that volume element.

The unit for kerma in air is the gray (Gy)

$$1\ \text{Gy} = 1\ \text{J/kg}$$

NOTE — *Kerma in air* is used instead of exposure whose unit was the röntgen (R)

$$1\ \text{R} = 2{,}58{,}10^{-4}\ \text{C/kg}$$

1) Personal photographic dosemeters are a particular class of individual dosemeters which represent a fraction of the existent absorbed dose measuring devices.

2) For many emulsions, 1 rem of fast neutrons causes the same density as does 200 μGy of 1 MeV gamma radiation.

In the energy range under consideration, it is considered that :

1 Gy is equivalent to 115 R, so that 1 R is equivalent to 8,69 mGy.

3.4 absorbed dose D[1] : The quotient of the mean energy imparted to matter ΔE_D in a volume element suitably small by the mass Δm of that volume element.

The unit of absorbed dose is the gray (Gy) :

$1\ Gy = 1\ J \cdot kg^{-1} = 100\ rd$

In this International Standard, the matter considered is air.

3.5 calibration curve : Curve representing, for a given radiation, the value of the optical density of the emulsion expressed under given conditions as a function of the dose in air.

3.6 optical density (transmission) : The common logarithm of the ratio of the incident luminous flux to the luminous flux transmitted by the sample.

3.7 optical density (reflection) : The common logarithm of the ratio of the luminous flux received by the sample at an incidence of 45° to the luminous flux perpendicularly diffused by the sample.

3.8 latent image : Invisible change which occurs within the silver halide crystals when an emulsion is exposed to an actinic radiation or to a radiation directly or indirectly ionising and which will "appear" upon processing to produce a visible silver image.

3.9 stability of latent image : Property of the latent image to produce images through processing that are as identical to one another as possible whatever the time period observed between their formation and development and whatever the ambient effects undergone during this period (temperature or humidity variation).

3.10 solarization : An inversion phenomenon occurring past a certain exposure or a certain absorbed dose beyond which the densities obtained diminish instead of increasing.

3.11 maximum beta energy (E_{max}) of a beta emitter : The maximum value of the complete energy spectrum of the beta radiation associated with the considered source.

4 Description

Personal photographic dosemeters are generally made up of two parts :

a) the film packet, consisting of

— a protective wrapping which protects the photosensitive part against the effect of light as well as against outside chemical and mechanical agents;

— a photosensitive part enclosed in the protective wrapping from which it should not be removed before processing, and consisting of one or more emulsions coated on one or more thin bases. If several emulsions are used, they may be either juxtaposed or superimposed on the same side of one base, or coated on both sides of one base or coated on different bases.

b) one or more filters included in a holder either separate from the packer or combined with it.

Each dosemeter should also have some means of identification (see clause 8).

5 Classification and designation

5.1 Classification

Personal photographic dosemeters can be classified as below :

5.1.1 Classification of dosemeters according to the dose scale

Three principal classes can be distinguished according to the dose scale which the dosemeters are to accommodate :

Class A : Dosemeters for monitoring in radiological protection able to be used for a range from about 200 µGy to about 50 mGy (i.e. approximately 20 mR to 5 R).

Class B : Dosemeters for monitoring in radiological protection able to be used for at least the range 600 µGy to 4 Gy[2] (i.e. approximately 60 mR to 400 R).

Class C : Dosemeters for emergency use able to be used for a range from about 100 mGy to at least 10 Gy (i.e. approximately 10 R to at least 1 000 R).

The range of doses frequently requires the dosemeters to contain serveral emulsions of different sensitivities.

5.1.2 Classification of dosemeters according to the radiation energy range

Dosemeters can be assigned to one of the following five divisions on the basis of the radiation energy range at which the dosemeter response meets the specifications in clause 6 :

Division 1 : Dosemeters for X and γ energies having a lower limit of about 250 keV, a range where the response is practically independent of the energy.

Division 2 : Dosemeters for all or part of the range of X and γ energies from about 20 keV to about 250 keV, a range where the response is specifically dependent on the energy.

1) Also more simply mentioned as "dose" in this International Standard.

2) This International Standard lays down the specifications of class B dosemeters for doses of between 600 µGy and 4 Gy only. For doses above and below this range, the supplier should state the dosemeter characteristics [see clause 6 b)].

Division 3 : Dosemeters that can be used over the entire range of X and γ energies from about 20 keV to 3 MeV.

Division 4 : Dosemeters designed for the measurement of beta radiation with maximum energies from 0,6 MeV to 3 MeV.

Division 5 : Dosemeters designed for the measurement of beta radiation with maximum energies from 1,5 MeV to 3 MeV.

5.1.3 Classification of dosemeters according to their resistance to water vapour

One of the two following categories applies to dosemeters, according to their resistance to water vapour :

Category W[1] : Dosemeters complying with the specifications of clause 6 j) (resistance to water vapour).

Category Y : Dosemeters which do not comply with the specifications of clause 6 j).

5.2 Designation

Photographic dosemeters are designated by their class and division, by their category, and by the number of emulsions, followed by reference to this International Standard.

Example of designation : Personal photographic dosemeter, B 1W, 3 emulsions, ISO 1757.

1) The dosemeters complying with these specifications generally have sufficient resistance to the penetration of chemical agents. Under certain working conditions, in the presence of a large quantity of substances such as mercury, ammonia, or hydrogen sulphide, or in hot or humid atmospheres, the dosemeters should comply with special requirements giving better sealing, verified for example by a mercury test.

6 Specifications

Characteristics	Requirements	Testing procedure : sub-clause No.
a) **Opacity to light** (for the package)	No measurable difference in the optical density of the useful portion in comparison with the control specimen.	7.2.1
b) **Constancy of the response of the emulsion** whose sensitivity permits the reading of the dose in question in the range from 600 µGy to 4 Gy. NOTE — For this characteristic as well as for the following ones, in case the dosemeter response is determined by adding the responses of various emulsions, the aggregate of these emulsions should be considered as a single emulsion.	Should this measuring range be covered by several emulsions of different sensitivity, the overlapping of two consecutive emulsions shall be equal to at least 20 % of the upper limit of the measurable dose of the most sensitive emulsion. **Divisions 1 to 3** For the dose corresponding to the quasi-linear part of the characteristic curve of the emulsions, the arithmetic mean of the absolute values of the deviation observed between the dose received and the dose read on the emulsion or emulsions should not be more than 20 % of the dose received for dosemeters of divisions 1 and 2 and 35 % for dosemeters of division 3. No individual deviation should exceed 30 % of the dose received for dosemeters of divisions 1 and 2 and 45 % for dosemeters of division 3. In the particular case of the dose limits, the values of the above deviations must be multiplied by 1,5. **Divisions 4 and 5** The arithmetic mean of the absolute values of the deviations observed between the dose received and the dose read on the emulsion or emulsions should not be more than 40 % of the dose received. No individual deviation should exceed 50 % of the dose received. In the particular case of the dose limits, the values of the above deviations must be multiplied by 1,5. NOTE — In this International Standard, the upper and lower limits of sensitivity of the emulsions are taken to be those stated by the manufacturer. Similarly, when the dosemeter is specified for below 600 µGy or above 4 Gy, the manufacturer should indicate the accuracy obtained in the corresponding ranges.	7.2.2
c) **Resistance to ageing** (either artificial or natural)	1) Deviations established in comparison with the control specimens not greater than 20 % of the dose received. 2) Variation of the optical density of the base fog in comparison with the control specimens not greater than 0,10.	7.2.3
d) **Stability of the latent image** after storing for 7 days.	Deviations found in comparison with the control specimens not more than 10 % of the dose received.	7.2.4
e) **Resistance to solarization** for a dose about twice that of the maximum dose of the dosemeter.	Dose determined on each emulsion, at least equal to the maximum dose for which it is intended.	7.2.5

Characteristics	Requirements	Testing procedure : sub-clause No.
f) **Isotropy** (comparison of an irradiation during rotation and an irradiation in a fixed position for energies at or above 40 keV)	**Division 1** Average of the deviations found in comparison with the control specimens not more than 20 % of the dose received. **Divisions 2 and 3** Average of deviations found in comparison with the control specimens not more than 30 % of the dose received. **Divisions 4 and 5** This test is not applicable.	7.2.6
g) **Checking of non-influence reversal** (comparison of measured doses received with normal incidence and in a fixed reversed position after rotation through 180°. Beta radiation of maximum energy not less than 1 MeV[1)]	**Divisions 1 to 3** This test is not applicable. **Divisions 4 and 5** Average of the doses indicated to be not more than twice or less than one-half of the dose received.	7.2.7
h) **Effect of energy**	**Divisions 1 to 3** See b), *Constancy of response.* **Division 4** The doses read using the calculation coefficients given by manufacturer shall satisfy the requirements indicated in b). **Division 5** This test is not applicable.	7.2.2
Dosemeters of category W		
j) **Resistance of wrapping to water vapour**		7.2.8
1) Latent image fading	Average of deviations found in comparison with the control specimen not more than 10 % of the dose received.	
2) Variation in response	Average of deviations found in comparison with the control specimen not more than 10 % of the dose received.	
3) Variation in optical density of the background	Average of deviations found in comparison with the control specimen not more than 0,05.	

1) This test is optional.

7 Test procedure

7.1 General test conditions

These tests are type tests for the evaluation of the performance of dosemeters. Some of these tests may be appropriate to determine constancy of performance.

7.1.1 Specifications for dosemeters undergoing test and for reference dosemeters

Dosemeters undergoing test and reference dosemeters shall be identical to the dosemeters by means of which the calibration curves were established, particularly with regard to the number and nature of the filters.

The test and control dosemeters shall be provided with identification markings along the lines arranged by the manufacturer.

The control dosemeters shall be taken from the same manufacturing batch as the test dosemeters.

NOTE — All the tests should be carried out without using a phantom.

7.1.2 Pre-test conditioning

Dosemeters undergoing test and reference dosemeters shall, before any test, be placed for at least 4 h but not more than 20 h in an ambient atmosphere having a temperature of 20 ± 2 °C and a relative humidity between 45 % and 75 %. The background rate shall not exceed a rate of kerma in the air of 0,25 μGy/h (approximately equivalent to 30 μR/h).

7.1.3 Test conditions

Unless otherwise stated below, testing shall be performed at a temperature of 20 ± 2 °C and relative humidity between 45 % and 75 %. The background rate shall not exceed a rate of kerma in the air of 0,25 μGy/h.

7.1.4 Reference radiations

7.1.4.1 Dosemeters of divisions 1 to 3

The X and γ radiations to which the dosemeters are exposed during the tests described below, and which are chosen from among those listed below, have energies which are included within the scale to be covered by these dosemeters :

a) Narrow spectrum series

Table A[1]	Table B[1]
23,2 keV, fluorescent X	33 keV, filtered
49,1 keV, fluorescent X	48 keV, filtered
66,8 keV, fluorescent X	65 keV, filtered
98,4 keV, fluorescent X	83 keV, filtered
161 keV, filtered X	161 keV, filtered
248 keV, filtered X	248 keV, filtered
662 keV, γ from caesium 137	662 keV, γ from caesium 137
1 250 keV, γ from cobalt 60	1 250 keV, γ from cobalt 60
as optional	
60 keV, γ from americium 241	
100 keV, filtered X	
118 keV, filtered X	
205 keV, filtered X	

b) Wide spectrum series[2]

45 keV, filtered X
79 keV, filtered X
104 keV, filtered X
169 keV, filtered X
202 keV, filtered X

as optional

58 keV, filtered X
134 keV, filtered X

The characteristics of these radiations, the methods for producing them and the geometrical conditions are described in ISO 4037.

NOTE — There must be electronic equilibrium in the air surrounding the samples. If, for environmental reasons, this requirement cannot be met, appropriate absorbers have to be placed in front of the sample to ensure electronic equilibrium. This subject shall be dealt with in a separate International Standard.

The sources used shall be such that the rate of kerma in the air is high enough not to have to take into account a change in the latent image on the sensitive emulsion during irradiation.

7.1.4.2 Dosemeters of divisions 4 and 5

The radiations to which the dosemeters are exposed during the tests described below have energies which are included within the scale to be covered by these dosemeters. A future International Standard will give the characteristics of these radiations, the methods for producing them and the geometrical conditions.

The sources used shall be such that the absorbed dose rate is high enough not to have to take into account a change in the latent image on the sensitive emulsion during irradiation.

1) Since the two tables may lead to different results, it is recommended that table A be used for testing energy response.

2) Wide spectrum series shall only be used in the case where important dose rates are necessary.

7.1.5 Method of processing emulsions and determining the dose

The tests described below cover both dosemeters provided to users who will determine the dose themselves and dosemeters which are processed and interpreted by the supplying organization.

The processing of the emulsions (either of test or of control dosemeters) and the determination of their optical density and their interpretation shall be carried out in each test described in 7.2, according to the directions furnished by the supplier of the dosemeters.

The determination of the dose shall be made from the optical density[1] by means of the calibration curve provided by the supplier and corresponding to the radiation to which the particular dosemeter will have been exposed.[2]

NOTE — When the dose is determined by an organization other than the user, the tests described in 7.2 being conducted outside of this organization, the processing of the emulsions, and the determination of their optical density and of the dose should be undertaken by the organization itself, using its own methods and the calibration curves which it uses in practice to determine the dose received by the users of these dosemeters.

7.1.6 Dosemeters calibrated while rotating[3]

The tests described in 7.2 have been drawn up on the assumption that the calibration curves are established by means of irradiation during the course of which the dosemeters are in a fixed position. If, on the contrary, the calibrations are effected by means of irradiation during which the dosemeters are rotating, this latter condition shall be reproduced in the course of the tests specified in 7.2.2, 7.2.3, 7.2.4, 7.2.5 and, if necessary, 7.2.7. During tests specified in 7.2.6, the dosemeters regarded as reference and those undergoing test play an inverse role to that described in the text.

7.2 Procedures

7.2.1 Checking the opacity of the package

After marking, expose a dosemeter to an illumination of 1 000 lx for 1 h at sufficient distance from the light source to avoid the dosemeter temperature exceeding 30 °C. Set one dosemeter face perpendicular to the luminous radiation. Next expose the other face of the dosemeter under the same conditions for 1 h. Then expose each edge of the dosemeter under the same conditions for 1 h. This dosemeter is processed simultaneously with a control dosemeter and their optical densities are compared either by observation (in the case of streaks or a lack of homogeneity) or by means of a densitometer (in the case of uniform fog).

7.2.2 Determination of constancy of response

The test shall be carried out by means of each of the reference radiations selected among these given in 7.1.4, having an energy in the range corresponding to the division of the dosemeter being tested.

The whole of the procedure described below shall be applied for each of the radiations in question.

For all dosemeters for which the determination of accuracy is carried out, the following operations shall be performed :

— five dosemeters to receive a dose corresponding to the lower limit of the dose scale;

— five dosemeters to receive a dose corresponding to twice the lower limit of the dose scale;

— five dosemeters to receive a dose corresponding to 50 % of the upper limit of the dose scale;

— five dosemeters to receive a dose corresponding to 80 % of the upper limit of the dose scale;

— five dosemeters to receive a dose corresponding to the upper limit of the dose scale.

In addition, for dosemeters containing several emulsions, perform the following operations :

— five dosemeters to receive a dose corresponding to the middle of the exposure range of each emulsion;

— five dosemeters to receive a dose corresponding to the centre point of each range of overlap of two emulsions.

The processing, determination of optical density and determination of dose shall be carried out as specified in 7.1.5.

The deviation between the actual dose received by the dosemeters and the dose recorded on each emulsion shall be determined and the arithmetic mean of the absolute values of these deviations calculated for each group of five dosemeters.

7.2.3 Testing the dosemeter for resistance to ageing[4]

7.2.3.1 Artificial ageing

This test shall be carried out on each of the constituent emulsions of the dosemeter.

Place a group of four unexposed dosemeters for 7 days in a dry oven[5] set at a temperature of 50 ± 1 °C.

1) The optical density shall be measured according to ISO 5 for transmission densities or according to a future International Standard in preparation, for reflection densities.

2) Users interpreting their own results should prepare their own calibration curves.

3) This sub-clause does not concern the dosemeters of divisions 4 and 5.

4) This test requires only that each dose value is given to a single dosemeter but it is desirable to carry out the test on a larger number of dosemeters (for example three to five).

5) Oven in communication with its surroundings, with no source of humidity or desiccant.