JIS

Optically stimulated luminescence dosimetry systems

JIS Z 4339:2004

Investigated by
Japanese Industrial Standards Committee

（JEMIMA／JSA）

2016/03/20

(Issued by the Japanese Standards Association)

解　!Syntax Error,!

　この規格についての意見又は質問は，上記原案作成者又は経済産業省産業技術環境局 標準課産業基盤標準化推進室（〒100-8901　東京都千代田区霞が関 1 丁目 3-1）にご連絡ください。

　なお，日本工業規格は，工業標準化法第 15 条の規定によって，少なくとも 5 年を経過する日までに日本工業標準調査会の審議に付され，速やかに，確認，改正又は廃止されます。

Foreword

Japan Electronic Measuring Instruments Standardization and Japan Standards Association applied states that the industrial standard should be enacted through deliberation by Japan Industrial Standards Committee to Minister of Economy, Trade and Industry. Be aware that there is a possibility of a patent application after applying this Standard, utility models, and after utility model applications are published.   The Minister of Economy, Trade and Industry and Japan Industrial Standards Committee will not have responsivity in confirming patent rights, patents after application, utility model, and utility model after application.

Contents

Japanese Industrial Standards
JIS
Z 4339 : 0000

Optically stimulated luminescence dosimetry systems

1. SCOPE

This standard describes the optically stimulated luminescence dosimetry system. An optically stimulated luminescence personal monitoring system shall be capable of measuring the doses received from the following kinds of radiation

a) **Optically stimulated luminescence personal monitoring system**

Photon energy or effective energy of 10 keV ~ 3 MeV X-ray and γ-ray received by the body from an external source for personal dose equivalent $H_p(10)$ or personal dose equivalent H_p (0,07) and maximum energy of 0.5 ~ 3 MeV for personal dose equivalent H_p (0,07) received by the body from an external source by β-ray.

b) **Optically stimulated luminescence dosimetry systems for work place environment monitoring**

Photon energy or effective energy of 10 keV ~ 3 MeV X-ray and γ-ray received by the body from an external source for both the ambient dose equivalent $H^*(10)$ or directional dose equivalent $H'(0,07)$.

c) **For environmental monitoring optically stimulated luminescence dosimetry systems**

An optically stimulated luminescence dosimetry system shall be capable of measuring the air absorbed dose or air Kerma for photon energy of 30 keV ~ 3 MeV.

2. **NORMATIVE REFERENCES**

The following standards listed below, by being quoted in this standard, constitute provisions of this standard. These normative references are to apply to the latest edition (including any amendments.).

JIS Z 4001   Nuclear terms

JIS Z 4331   X ray, γ-ray and β-ray personal dosimeter calibration phantom

JIS Z 4511   Method of calibrating a radiation dose measuring instrument and dose equivalent
measuring instrument.

JIS Z 8103   Measurement terms

3. **DEFINITION**

Definition of the main terms used in this standard includes the definition of terms from JIS Z 4001, JIS Z 4332, JIS Z 4511 and JIS Z 8103.

a) **Optically stimulated luminescence**

Light emission phenomenon caused by the stimulation of light with a specific wavelength to a material irradiated with radiation.

b) **Optically Stimulated Luminescence Dosimetry Element**

Made by forming a material capable of optical stimulation luminescence into sheets; a rod shape, which can be repeatedly made using a regeneration process.

c) **Holder**

This is the container that holds the optically stimulated material or element.

d) **Dosimeter**

Accommodate the dosimetry element in the holder as well as the user's personal information or the environment information. A device used to measure an absorbed dose by Ionizing Radiation.

e) **Reader**

The reader is used to stimulate the irradiated material with a specific wavelength of light. The amount of luminescence measured by the reader indicates the amount corresponding to the dose measured by the device.

f) **Optically stimulated luminescence dosimetry system**

The system includes the dosimeter, the reader, the bleaching/annealing process apparatus, and the recording apparatus.

g) **Indicated value**

The measured value of the amount of light emission by the optically stimulated luminescence material or element.

h) **Evaluated value**

For the 1 cm deep dose equivalent, it is calculated based from the indicated value. For the 70 μm shallow dose equivalent, it is approximately the value of the air absorbed dose or air Kerma. Calculation method in this case shall be either incorporated in the measuring device feature or according to the manufacturer's instructions or measurement service agency.

i) **Reusability**

The Optically stimulated luminescence dosimeters (OSL) can be reused by going through a bleaching process. The process of bleaching exposes the irradiated dosimeter to a specific wavelength of light in order to remove the excited states of the optically stimulated luminescent material of the element. In addition to utilizing a light emitting device of a specific wavelength, there is a case called annealing, where the process uses a heat treatment furnace in order to remove the excited states of the Optically Stimulated Luminescent material.

j) **Residual dose**

Indicated value or Evaluated value obtained when measuring a dosimeter after the Bleaching/Annealing process.

k) **Lower detection limit**

The lower detection limit is the lowest evaluated/measured value of the non-irradiated dosimeter at a 95% level of confidence interval.

l) **Reader background**

Measurement of the background noise and standards of the reader.

Note: Do not insert the dosimeter, or Indicated value or Evaluated value when obtaining the reader background measurement.

m) **Fading**

A phenomenon in which the amount of dosimetric signal decreases as time elapses after irradiating the element with ionizing radiation

n) Initial fading

There is an initial fading for a short period of time after irradiation of dosimeter. It then becomes stable after the initial fading phenomenon.

o) Response

This corresponds to the dose of the evaluated value i.e. personal dose equivalent $H_p(10)$, ambient dose equivalent $H^*(10)$, personal dose equivalent $H_p(0.07)$, directional dose equivalent $H'(0.07)$, and air absorbed dose or air Kerma.

p) Relative response

The value obtained by dividing the response by the response from a reference.

q) Coefficient of variation（C）

The ratio of the standard deviation **S** to the mean $\bar{x}$

$$C = \frac{S}{\bar{x}} = \frac{1}{\bar{x}} \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

r) Remaining maximum energy

Beta ray energy is calculated by maximum residual particle range.

4. **TYPE AND TARGET DOSE**

Types of optically stimulated luminescence dosimetry systems; the application (target dose) either in personal/occupational workplace monitoring, or environmental monitoring.

a) Dose for personal monitoring

Personal monitoring in this standard include the personal dose equivalent $H_p(10)$ and the personal dose equivalent $H_p(0,07)$ that is expressed in units of Sievert (Sv).

b) Work place area/environment monitoring

Work place area/environment monitoring in this standard include the ambient dose equivalent $H^*(10)$ and the directional dose equivalent $H'(0,07)$ that is expressed in units of Sievert (Sv).

c) Absorbed dose for environmental monitoring

Environmental monitoring in this standard include the air absorbed dose and air Kerma that is expressed in units of Gray (Gy).

5. **STRUCTURE**

a) Optically stimulated luminescence dosimetry systems

Optically stimulated luminescence dosimetry systems includes the dosimeter, the reader, the annealing process apparatus as required, and the recording apparatus.

b) Dosimeter

The dosimeter has one or more optically stimulated luminescence material/elements housed in the holder with a convenient structure for mounting. In addition to the optically stimulated luminescence dosimeter, a paper clip may be provided for mounting.

c) Reader

The reader has an element excitation portion, a photoelectric conversion unit, photoelectric signal measurement unit, and an instruction section. In order to adjust the sensitivity of the reader at a constant, A light source may be provided for testing the reader.

6.　GENERAL GUIDELINES

6.1.　Common test conditions

Each performance test method is stated in chapter 7, Unless otherwise specified, according to Table 1.

Table 1　Common test conditions using optically stimulated luminescence dosimeter

Item	Conditions		
	Personal monitoring	Work place Area/environment monitoring	Environmental monitoring (For Air Kerma or Air Absorbed Dose)
Ambient temperature　　℃	20±5		
Relative humidity　　%	≦85		
Atmospheric pressure　　kPa	101.3±5.0		
In regard to personal monitoring 1 cm deep dose equivalent rate μSv/h	≦0.25	—	—
In regard to the location of the test Area/environment 1 cm deep dose equivalent rate　　μSv/h	—	≦0.2	—
Air absorbed dose rate of the test environment or air Kerma rate μGy/h	—	—	≦0.2
Indicated value of the dosimeter before irradiation	Less than or equal to the value specified by the manufacturer		
Temperature of the dosimeter after irradiation　　℃	20±5		
Power-supply voltage　　V	The rated value±1 %		
Power frequency　　Hz	The rated value±2 %		
Distortion factor of power waveforms for sine wave　　%	<5		
Warming up time of the reader　hrs.	≧0.5		

6.1.1　Calibration Equipment

Tests for 7.1.2 – 7.4.2 as well as 7.6.2 – 7.17.2, using sources and calibration equipment as defined in the JIS Z 4511.

6.1.2　Phantom

Use phantoms as defined by the JIS Z 4331.

6.2　Common test methods

Common test methods shall be as follows:

a)　Handling and operation of the optically stimulated luminescence dose measuring device shall be specified by the manufacturer.

b)　Verifying the test conditions of a specific item by changing the condition of that certain item; conditions other than the item to be tested are intended to be within the scope of the test conditions shown in Table 1.

c) The test is carried out on the dosimeter of the same lot and can be used for each test items repeatedly.

d) Measurement position of the test dose, i.e. the center postion of the dosimeter is specified by the manufacturer. Test dose and ± 20% of the values is specified in each test item.

e) When measuring the dose in personal monitoring using a phantom and an optically stimulated luminescence dosimeter, the dosimeter shall be placed as close as possible to the point of interest in the phantom.

f) In the case of personal monitoring using optically stimulated luminescence dosimetry systems, the tests for 7.1.2 a), 7.2.2 a), as well as for 7.4.2 and 7.6.2 is irradiated by placing a dosimeter on the phantom. In this case, the dose to the standard is the personal dose equivalent $H_p(10)$ or the personal dose equivalent $H_p(0.07)$. In air, the personal dose equivalent $H_p(10)$ or the personal dose equivalent $H_p(0.07)$ is obtained by multiplying conversion factors to the air Kerma (K_a). In accordance with the photon energy or effective energy, personal dose equivalent $H_p(10)$ from air Kerma (K_a) or personal dose equivalent $H_p(0.07)$ from air Kerma (K_a) is calculated by using conversion factors (f_{p10}) or $(f_{p0.07})$ and is obtained by the following equations.

$$H_p(10) = K_a \times f_{p10}$$
$$H_p(0.07) = K_a \times f_{p0.07}$$

where, f_{p10} Conversion factor for personal dose equivalent $H_p(10)$

  $f_{p0.07}$ Conversion factor for personal dose equivalent $H_p(0.07)$

It should be noted that conversion factors can be obtained from Annex 1 Table 1 and Annex 1 Table 2.

g) In the case of personal monitoring using optically stimulated luminescence dosimetry systems for test 7.5.2, it is irradiated by placing a dosimeter on the phantom. The dose to the criteria is the personal dose equivalent $H_p(0.07)$.

h) In the case of personal monitoring using optically stimulated luminescence dosimetry systems for test 7.1.2 b), it is irradiated by placing a dosimeter in air. The dose to the criteria is the personal dose equivalent $H_p(10)$. In this case, the evaluated value of the dosimeter (I) is used to obtain the apparent expected evaluated value when tested by using the phantom [hereinafter apparent evaluated value of (I_c) . This conversion is based from the following method.

The dosimeter placed on phantom, irradiated by 1 mSv or more by using γ-ray from [137]Cs. The evaluated value of the dosimeter obtained while placed on a phantom is indicated as I_{OP} . Next, irradiation under the same conditions without the phantom i.e. in air, obtains the evaluated value of the dosimeter in air indicated as I_{FA} , obtaining a conversion coefficient f_g by the following equation:

$$f_g = \frac{I_{OP}}{I_{FA}}$$

Apparent evaluated value (I_c) is obtained by multiplying the conversion factor f_g to the evaluated value of the irradiated dosimeter installed in air (I) as shown in the following equation.

$$I_c = I \times f_g$$

i) In the case of personal monitoring using optically stimulated luminescence dosimetry systems for tests items other than 6.2 f), 6.2 g) and 6.2 h), The irradiated dosimeter is set up in air. Dose to the criteria is the personal dose equivalent $H_p(10)$.

j) In the case of work place area/environment monitoring using optically stimulated luminescence dosimetry systems, the dosimeter is irradiated by placing it in air. Dose to the criteria is the ambient dose equivalent $H^*(10)$ and/or the directional dose equivalent $H'(0,07)$. The ambient dose equivalent $H^*(10)$ and directional dose equivalent $H'(0,07)$ is calculated by multiplying conversion factors (f^*_{10}) or $(f'_{0.07})$ to the kerma (K_a) and is shown in the following equations.

$$H^*(10) = K_a \times f^*_{10}$$
$$H'(0.07) = K_a \times f'_{0.07}$$

where,, f^*_{10} Conversion factor for ambient dose equivalent $H^*(10)$

$f'_{0.07}$ Conversion factor for directional dose equivalent $H'(0,07)$

It should be noted that, Conversion factor can be obtained from Annex 1 Table 3 and Annex 1 Table 4.

k) Dosimeters irradiated are installed in air. Dose to the criteria is the air absorbed dose (Da) or air Kerma (K_a).

7. TEST METHODS

7.1 Variations in the evaluated value

7.1.1 Performance

Variations in the evaluated value is tested by using method 7.1.2, the ratio between the maximum value and the minimum value of the evaluated value shall be 1.3 or less.

7.1.2 Test Method

a) Standard Format

Ten (10) dosimeters which were bleached/annealed are prepared. Using γ rays ^{137}Cs, the dosimeters are irradiated with a dose shown in Table 2, a reader is used to obtain the evaluated values and to determine the ratio between the maximum value and the minimum value of the evaluated value.

b) Acceptance testing

The number of dosimeters is determined by consultations between interested parties that take part in processing the element. Using γ rays ^{137}Cs, the dosimeters are irradiated with a dose shown in Table 2, a reader is used to obtain the evaluated values and to determine the ratio between the maximum value and the minimum value of the evaluated value.

Table 2. Conditions for variations test of the evaluated value

Item	Conditions		
	Personal monitoring mSv	Work place Area/environment monitoring mSv	Environmental monitoring mGy
Object dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2	0.2	0.2

7.2 Reproducibility of the evaluated value

7.2.1 Performance

The coefficient of variation of the evaluated value of each dosimeter shall be equal to 0.075 or less when the reproducibility of the evaluated value is tested by 7.2.2.

7.2.2 Test Method

a)   Standard Format

Ten (10) dosimeters which were bleached/annealed are prepared. The dosimeters are irradiated with a dose shown in Table 3 by γ-rays, and each dosimeter is read to obtain the evaluated value. The ten dosimeters are then bleached or annealed and the aforementioned process is repeated. This is performed 10 times for each dosimeter and the coefficient of variation is determined for each one.

b)   Acceptance testing

The number of dosimeters (n) is determined by consultations between interested parties that take part in processing the element. The dosimeters are irradiated with a dose shown in Table 3 by γ-rays and each dosimeter is read by a reader to find the evaluated value. The (n) number of dosimeters are then bleached or annealed and the aforementioned process is repeated. This is performed 10 times for each dosimeter and the coefficient of variation is determined for each one.

Table 3   Conditions for the reproducibility test of the evaluated value

Item	Conditions		
	Personal monitoring mSv	Work place Area/environment monitoring mSv	Environmental monitoring mGy
Object dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2	0.2	0.2

7.3 Dose Linearity

7.3.1 Performance

When tested by 7.3.2, the variation of the response shall be as follows.

a)   In the case of personal monitoring using optically stimulated luminescence dosimetry systems, Variation shall be less than 30% for 0.1 mSv (test dose i = 1), at a dose of 0.3 mSv or more (test dose i = 2,3,4,5,6) variation shall be 10% or less.

b)   In the case of work place area/environmental monitoring using optically stimulated luminescence dosimetry systems, variation shall be less than 30% at 0.03 mSv (test dose i = 1), at a dose of 0.1 mSv or more (test dose i = 2,3,4,5,6)   variation shall be 10% or less.

c) In the case of environmental monitoring using optically stimulated luminescence dosimetry systems, variations shall be less than 30% at 0.03 mGy (test dose i = 1), at a dose of 0.1 mGy or more (test dose i = 2,3,4,5,6) variation shall be 10% or less.

7.3.2 Test method

n-number of dosimeters which were bleached/annealed are prepared into six sets. The dosimeters in each set are irradiated with a dose shown on Table 4 by γ-ray and each dosimeter are read to obtain the evaluated value. The average value of the responses for each set is obtained to determine the acceptable range of response using the following formula:

$$0.7 \leqq \frac{\overline{R_i}}{R_0} \pm l \leqq 1.3 \quad \text{The first set where (i=1)}$$

$$0.9 \leqq \frac{\overline{R_i}}{R_0} \pm l \leqq 1.1 \quad \text{The second set where (i = 2,3,4,5,6)}$$

where, $\overline{R_i}$ i th test dose; average values of the response of an irradiated set from the six sets of dosimeters

$\overline{R_0}$ The average value of the set of response irradiated under reference dose

l It represents the width of the error, determined by Annex 2 Table 1.

Table 3   Conditions for dose linearity test

Item	Conditions		
	Personal monitoring mSv	Work place environment monitoring mSv	Environmental monitoring mGy
Target Dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H*(10)$	air Kerma (K_a)
Test dose	0.1 , 0.3 , 0.5 , 1 , 10 , 100	0.03 , 0.1 , 0.3, 0.5 , 1 , 10	0.03 , 0.1 , 0.3, 0.5 , 1 , 10
Reference dose	1	0.3	0.3

7.4   Photon energy response of the evaluated value

7.4.1   Performance

Characteristics of the evaluated value from photon energy, when tested by 7.4.2, the acceptable range of variation of the evaluated value from the photon energy shall be 30% or less.

7.4.2   Test method

n-number of dosimeters which were bleached/annealed are prepared into six sets. The dosimeters in each set are irradiated with a dose shown on Table 5 by X ray or γ-ray and each dosimeter is read to obtain the evaluated value. The average value of the responses for each set is obtained to determine the acceptable range of response using the following formula.

$$0.7 \leqq \frac{\overline{E_i}}{E_0} \pm l \leqq 1.3 \quad\quad\quad (i=1,2,3,4,5)$$

where, $\overline{E_i}$ i-th average value of the set of evaluated values irradiated with

X-rays or γ rays test energy

$\overline{E_0}$ The average value of the set of evaluated value irradiated by X-rays

or γ rays of reference energy

l It represents the width of the error, determined by Annex 2 Table 1.

The personal dose equivalent $H_p(0.07)$ and directional dose equivalent $H'(0,07)$ are not used for this test. Only X rays in the range of effective energy is used which is shown in Table 5. The acceptable range of the test X rays energy shall be within 10%.

Table 4   Conditions for the photon energy dependence test

item		Conditions		
		Personal monitoring	Work place Area/environment monitoring	Environmental monitoring
Object dose		personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose		2mSv	2 mSv	2 mGy
Test energy	X ray keV	25, 45, 80, 120	25, 45, 80, 120	35, 45, 80, 120
	γ ray MeV(^{60}Co)	1.25	1.25	1.25
Reference energy	γ ray MeV(^{137}Cs)	0.66	0.66	0.66

7.5 $β$-ray energy characteristics of the evaluated value

7.5.1   Performance

Characteristic of evaluated values from $β$-ray energy when tested by 7.5.2, the acceptable range of variation of the evaluated value by β-ray energy shall be 30% or less. It should be noted that this provision applies only to personal monitoring using optical stimulated luminescence dose measuring device for measuring the personal dose equivalent $H_p(0.07)$ by β-ray.

7.5.2   Test method

n-number of dosimeters which were bleached/annealed are prepared into two sets. The dosimeters for each set is irradiated with a dose shown in Table 6 and each dosimeter is read to obtain the evaluated value. From the average value of each set of evaluated value, the acceptable range is determined using the following equation

$$0.7 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.3 \qquad (i=1)$$

where, $\overline{E_i}$ i-th average value of the set of evaluated values irradiated with β

rays test energy

$\overline{E_0}$ The average value of the set of evaluated values irradiated with β rays

of reference energy

l It represents the width of the error, determined by Annex 2 Table 1

Table 5   Conditions for β-ray energy dependence test

Item			Conditions
			Personal monitoring
Object dose			personal dose equivalent $H_p(0.07)$
Test dose mSv			5
Test energy	β ray MeV		0.5
Reference energy	β ray MeV		1.8

Remarks **1.**   Nuclide of reference energy used is 90Sr / 90Y, and nuclide of test energy is 204Tl
or 85Kr.
2.   Energy represents residual maximum energy.

7.6   Angular dependence

7.6.1   Performance

Angular dependence characteristic of the evaluated value when tested by 7.6.2, the acceptable range of variation of the evaluated value shall be 20% or less. However, the angular dependence characteristic with respect to the X-ray in the vicinity of the effective energy 80 keV is a reference and does not need to specify the acceptable range.

7.6.2   **Test method**

n-number of dosimeters which were bleached/annealed are prepared into a number of sets as shown in Table 7. Each set is irradiated by γ-ray ^{137}Cs with test incident angles as shown in Table 7 and each dosimeter is read to obtain the evaluated value. From the average value $\overline{E_i}$ of each set of evaluated value, the acceptable range is determined by the following equation. $\overline{E_0}$ is determined by exposing n-number of dosimeters under the reference incident angle condition.

$$0.8 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.2 \quad \begin{array}{l} \text{(For personal monitoring} \quad i=1,\ 2,\ \cdots,\ 8) \\ \text{(For a work place Area/environment monitoring } i=1,\ 2,\ \cdots, \\ 12) \end{array}$$

where, $\overline{E_i}$ i -th average value of the set of evaluated values irradiated under the
test incident angle conditions

$\overline{E_0}$ The average value of the set of evaluated values irradiated from the
front (reference incident angle)

l It represents the width of the error, determined by Annex 2 Table 1

Table 6　Conditions for angular dependence characteristics of the evaluated value

Item	Conditions		
	Personal monitoring	Work place Area/environment monitoring	Environmental monitoring
Number of sets of test	9	13	13
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	2mSv	2 mGy
Test incident angle (The dosimeter front and 0 °)	$0°$, 　Horizontal $30°$, Horizontal $60°$ Vertical $30°$, 　vertical $60°$	$0°$, Horizontal　$30°$, Horizontal $60°$, Horizontal $90°$ 　Vertical $30°$, vertical　$60°$, vertical　$90°$	$0°$, Horizontal $30°$, Horizontal　$60°$, Horizontal $90°$ Vertical $30°$, vertical $60°$, vertical　$90°$
Reference incident angle	Vertical line perpendicular to the front side of a dosimeter (specified by the manufacturer)		

7.7　Fading

7.7.1　Performance

Fading of the evaluated value, when tested by method 7.7.2, the acceptable range of variation of the evaluated value shall be 10% or less at 20 ℃ and shall be 15% or less at 40 ℃.

7.7.2　Test method

n-number of dosimeters shall be prepared. In example, 13 dosimeters are prepared. Out of this 13 dosimeters, 4 dosimeters (must be bleached/annealed) would be irradiated, 4 dosimeters (must be bleached/annealed) would not be irradiated and the rest of the dosimeters would not be used until after the test storage period. The first 8 dosimeters that were used shall be stored at a certan period of time. The storage period and the test dose(from γ -ray) is based from Table 8 and are stored at an ambient temperature of 20 ± 5 ℃ or 40 ± 5 ℃. After the storage period, these 8 dosimeters would be read to obtain their evaluated values.

The dosimeters that were not yet used would then be prepared. They will be bleached/anealled, irradiated and read on the same measurement date of the first 8 dosimeters. The acceptable range is determined by using the following equation.

Relative to 20 ℃

$$0.9 \leqq \frac{\overline{E}_{iE} - \overline{E}_{iB}}{\overline{E}_0} \pm l \leqq 1.1 \qquad (i=1, 2, 3)$$

Relative to 40 ℃

$$0.85 \leqq \frac{\overline{E}_{iE} - \overline{E}_{iB}}{\overline{E}_0} \pm l \leqq 1.15 \qquad (i=1, 2, 3)$$

where, $\overline{E}_{iE}$ Average value of the evaluated values obtained under certain storage period for the set of pairs that are irradiated.

$\overline{E}_{iB}$ Average value of the evaluated values obtained from the set of pairs under a certain storage period without irradiation.

$\overline{E}_0$ The average value of the evaluated values obtained from the pairs that were irradiated and read after the storage period.

l It represents the width of the error, determined by Annex 2 Table 1.

Incidentally, Methods to eliminate the influence of the initial fading is specified by the manufacturer, e.g. for all dosimeters, measurement prior to treatment, requires storage for a certain period of time before reading the dosimeter

Table 7   Conditions to test fading of the evaluated value

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	3mSv	3 mSv	3 mGy
Test storage period	7 days, 30 days, 90 days		
Test temperature	20℃and 40℃		

7.8   Lower limit of detection
7.8.1   Performance
The lower limit of detection, when tested by 7.8.2, shall not exceed the following values.

a)   In the case of personal monitoring using optically stimulated luminescence dosimetry system, 0.1mSv

b)   In the case of work place area/environment monitoring using optically stimulated luminescence dosimetry system, 0.03 mSv

c)   In the case of optically stimulated luminescence dosimetry system for environmental monitoring, 0.03 mSv

7.8.2   Test method
n-number of dosimeters which were bleached/annealed are prepared. These non-irradiated dosimeters are read to obtain the evaluated value. The standard deviation value S is determined from the evaluated values and the lower detection limit can be obtained by using the following formula:

$$t_n \times S \leqq H$$

where, H In the case of the personal monitoring optically stimulated luminescence dosimetry systems, 0.1 mSv, the case of the work place area/environment monitoring or for environmental monitoring using optically stimulated luminescence dosimetry systems, 0.03 mSv or 0.03 mGy.

t_n Value of the degrees of freedom n-1 in the test, determined by Annex 2 Table 2.

7.9   Residual dose

7.9.1 Performance

The residual dose, when tested by method 7.9.2, shall not exceed the detection limits that is defined in 7.8. Furthermore, the acceptable range of variation of the evaluated value shall be 10% or less

7.9.2 Test Method

a) Effect on the detection limit

n-number of dosimeters which were bleached/annealed are prepared. These dosimeters are irradiated based from Table 9 by γ-ray and each dosimeter is read for checking the dose. After reading, the dosimeters are annealed and the test method of 7.8.2 is then performed.

b) Effect on the evaluated value

n-number of dosimeters which were bleached/annealed are prepared. A set of dosimeters are irradiated with a test dose based from Table 9 by γ rays, the set is bleached/annealed and irradiated again using the residual test dose also from Table 9 and each dosimeter is read to obtain the evaluated value. A set of dosimeters which underwent the bleaching/annealing process is irradiated with only the residual dose test dose from table 9 and is also read to obtain its evaluated value.

The varaition of the evaluated value is determined by using following formula

$$0.9 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.1 \qquad (i=1)$$

where,

l It represents the width of the error, determined by Annex 2 Table 1.

$\overline{E_i}$ The average value of the set of evaluated values irradiated with the test dose and the residual test dose

$\overline{E_0}$ The average value of the set of evaluated values irradiated with only the residual test dose

Table 8   Conditions of the residual dose test

Item	Conditions		
	Personal monitoring mSv	Work place environment monitoring mSv	Environmental monitoring mGy
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
The residual test dose	100	10	10
Test dose	2	0.2	0.2

7.10 Stability of the dosimeter to light

7.10.1 Performance

Stability to light, when tested by method 7.10.2, shall not exceed the detection limits of the evaluated value that is defined in 7.8. Furthermore, the acceptable range of variation of the evaluated value shall be 10% or less.

7.10.2 Test method

a) Effect on the detection limit

n-number of dosimeters which were bleached/annealed are prepared. After irradiating with light under the conditions shown in Table 10, test by using method 7.8.2.

b) Effect on the evaluated value

Two sets of n-number of dosimeters which were bleached/annealed are prepared. Each set is irradiated based from table 10 by γ-ray. In one set, it is irradiated with light under the conditions shown in Table 10 and read afterwards. The other set is stored in dark room and read at the same place.

The variation of the evaluated value is determined by using following formula

$$0.9 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.1 \qquad (i=1)$$

where, l It represents the width of the error, determined by Annex 2 Table 1.

            $\overline{E_i}$ The average value of the set of evaluated values that were exposed under the conditions given in table 10

            $\overline{E_0}$ The average value of the set of evaluated values from the dark room storage

Table 9   Conditions for stability test of the dosimeter to light

Item	条件		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy
light irradiation conditions for the test on the effect to the detection limit	Xenon discharge lamp, ultra-high pressure mercury lamp shuts off light wavelength below 300 nm Or daylight color by using a fluorescent lamp, 3 klx or more, irradiate for more than 24 hours		
light irradiation conditions for the test on the effect to the evaluated value	Xenon discharge lamp, ultra-high pressure mercury lamp shuts off light wavelength below 300 nm Or daylight color by using a fluorescent lamp, 3 klx or more, irradiate 168 hours or more		

7.11 Stability of the dosimeter to temperature

7.11.1 **Performance**

The stability of the dosimeter with respect to temperature, when tested by method 7.11.2, the acceptable range of variation of the evaluated value shall be 5% or less.

7.11.2 **Test method**

Two sets of n-number of dosimeters which were bleached/annealed are prepared. One set of n-number of dosimeters are irradiated under test conditions and the other set of n-number of dosimeters are irradiation under the reference condition. Test conditions are shown in Table 11 as well as the dose used to irradiate dosimeters for the test. Read the dosimeters to obtain evaluated values. From the average of the evaluated value, determine the variation on the evaluated value by using the following equation.

The variation of the evaluated value is determined by using following formula

$$0.95 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.05 \qquad (i=1, 2)$$

where, $\overline{E_i}$ The average value of the set of evaluated values read under test environment condition

$\overline{E_0}$ The average value of the set of evaluated values read under the reference condition

l It represents the width of the error, determined by Annex 2 Table 1

Table 10   Conditions for stability test of the dosimeter to temperature

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	2 mSv	2 mGy
Test environment conditions	Temperature -10 $\pm$ 2 ℃ and the temperature 40 $\pm$ 2 ℃		
Reference condition	Temperature 20 $\pm$ 2 ℃		

7.12 The stability of the dosimeter to humidity

7.12.1 Performance

Stability of the dosimeter to humidity, when tested by 7.12.2, the variation of the evaluated value shall be 5% or less.

7.12.2 Test method

Two sets of n-number of dosimeters which were bleached/annealed are prepared. Each set is irradiated based with a test dose from table 12 by γ rays. One set is to be irradiated under test conditions and the other set to be irradiated under reference conditions shown in Table 12. After irradiation, each set is stored under the same conditons and read after the storage period to obtain the evaluated values.

The varaition of the evaluated value is determined by using following formula

$$0.95 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.05 \qquad (i=1)$$

where, l It represents the width of the error, determined by Annex 2 Table 1

$\overline{E_i}$ The average value of the set of evaluated values read under test environment condition

$\overline{E_0}$ The average value of the set of evaluated values read under the reference condition

Table 11   Conditions for stability test of the dosimeter to humidity

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy
Test conditions	Temperature 40 ± 2 ℃, the relative humidity of 90% or more, stored for more than 48 hours		
Reference conditions	Temperature 40 ± 2 ℃, the relative humidity of 50% or more, stored for more than 48 hours		

7.13   Stability of the dosimeter when dropped

7.13.1   Performance

Stability of signal when a dosimeter is dropped is tested by method 7.13.2, the acceptable range of variation of the evaluated value shall be 10% or less.

7.13.2   Test method

Two sets of n-number of dosimeters which were bleached/annealed are prepared. One set is dropped using the conditions shown in Table 13 while the other set is not dropped. The two sets are read simultaneously to determine the evaluated value.

The varaition of the evaluated value is determined by using following formula

$$0.9 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.1 \qquad (i=1)$$

where, l It represents the width of the error, determined by Annex 2 Table 1

$\overline{E_i}$ The average value of the set of evaluated values read from the set that used the drop conditions

$\overline{E_0}$ The average value of the set of evaluated values read from the set that was not dropped

Table 12   Conditions for stability test when dropping dosimeters

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy
drop conditions	Dropped once from a height of 1 m to a concrete floor.		

7.14   Reusability

7.14.1 Performance

Test for reusability is done based by using method 7.14.2, the acceptable range of variation of the evaluated value shall be 10% or less.

7.14.2 Test method

n-number of dosimeters which were bleached/annealed are prepared. The dosimeters are irradiated with a test dose based from Table 14 by γ rays and each dosimeters are read to get an average $\overline{E}_0$ value of the evaluated values. This will act as the reference. Then, these dosimeters are bleached/annealled and irradiated again using the test dose from Table 14 and each dosimeters are read to obtain the average value $\overline{E}_i$ of the evaluated value. The variation of the evaluated value can be determined by using the following equation.

$$0.9 \leqq \frac{\overline{E}_i}{\overline{E}_0} \pm l \leqq 1.1 \qquad (i=1)$$

where, l : It represents the width of the error, determined by Annex 2 Table 1

It should be noted that the number of times the dosimeters can be reused or the lifetime of the dosimeter is based from the manufacturer's specifications. The usual number of times an optically stimulated luminescence dosmeter can be used is 100 times or more.

Table 13   Conditions for reusability test

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy

7.15   **Stability of the reader to variations in the power supply voltage**

7.15.1   **Performance**

Stability of the reader to variations in power supply voltage, when tested by 7.15.2, the acceptabe range of variation of the evaluated value shall be 10% or less.

7.15.2   **Test method**

n-number of dosimeters which were bleached/annealed are prepared. The dosimeters are irradiated with a test dose based from table 15 by γ-ray and each dosimeter is read to obtain the average of the evaluated value. This will act as the reference $\overline{E}_0$. Then, the supply voltage of the reader is adjusted based on the conditions from Table 15. n-number of dosimeters are irradiated in this condition and read to obtain the average of the evaluated value $\overline{E}_i$. To determine the variation of the evaluated value, use the following equation.

$$0.9 \leqq \frac{\overline{E}_i}{\overline{E}_0} \pm l \leqq 1.1 \qquad (i=1, 2)$$

where, $\overline{E}_i$: The average value of the set of evaluated values read by adjusting the reader to the i test supply voltage (rated voltage adjustment)

          $\overline{E}_0$: The average value of the set of evaluated values read from the reference power supply voltage

          l : It represents the width of the error, determined by Annex 2 Table 1

Table 14   Conditions for stability test of the reader with respect to variations in the power supply voltage

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy
Test power supply voltage	Rated voltage +10% and rated voltage -10%		
Reference power supply voltage	Rated voltage		

7.16 Stability of the reader to temperature

7.16.1 Performance

The stability of the reader with respect to temperature is tested by method 7.16.2, the acceptable range of variations in the background of the reader, shall be within 0.2 times the detection limit specified in 7.8. Furthermore, the allowable range of the variation of evaluated values shall be 10% or less.

7.16.2 Test method

a) Effect on the background

Place the reader under the test environment temperature and the reference environment temperature from Table 16. Do not insert an irradiated test dose dosimeter in the reader while the reader is being exposed in the environmental temperature conditions. After 24 hours or so, do n times of reading to obtain the average background $\overline{E}_i$ and $\overline{E}_0$ of the reader from both environmental temperature conditions. The variation in the background of the reader is obtained by using following equation.

$$\left(\overline{E}_i - \overline{E}_0\right) \pm l \qquad (i=1, 2)$$

where, $\overline{E}_i$: The average value of the set of evaluated background values read on based from i th test environment temperature

$\overline{E}_0$: The average value of the set of evaluated background values read based from the reference environmental temperature

l : It represents the width of the error, determined by Annex 2 Table 1.

b) Effect on the evaluated value

n-number of dosimeters which were bleached/annealed are prepared. The dosimeters are irradiated with a test dose from Table 16 by γ-ray. The reader is placed under the influence of the test environmental temperature or the reference environmental temperature for 24 hours. After 24 hours or so, while maintaining the environmental temperature conditions, read the n number of dosimeters that are exposed as test dose.

The varaitions of the evaluated value is determined by using following formula

$$0.9 \leqq \frac{\overline{E}_i}{E_0} \pm l \leqq 1.1 \qquad (i=1, 2)$$

where, $\overline{E}_i$: The average value of the set of evaluated values read under test

environment temperature

$\overline{E_0}$: The average value of the set of evaluated values read under reference
environmental temperature

l : It represents the width of the error, determined by Annex 2 Table 1

Table 15   Conditions for stability test of the reader with respect to temperature

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy
Test environment temperature	5 ± 2 ℃ and 40 ± 2 ℃ (left for 24 hours or more.)		
Reference environment temperature	20 ± 2 ℃ (left for 24 hours or more.)		

7.17   Stability of the reader to humidity

7.17.1   Performance

The stability of the reader with respect to humidity, when tested by 7.17.2, the acceptable range of variation in the background of the reader shall be within 0.2 times the detection limit specified in 7.8. Furthermore, the acceptable range of the variation of evaluated values shall be 10% or less

7.17.2   Test method

a)   Effect on the background

Place the reader under the test environment humidity and the reference environment humidity from Table 17. Do not insert an irradiated test dose dosimeter in the reader while the reader is being exposed in the environmental humidity conditions. After 24 hours or so, do n times of reading to obtain the average background $\overline{E_i}$ and $\overline{E_0}$ of the reader from both environmental temperature conditions. The variation in the background of the reader is obtained by using following equation.

$$\left(\overline{E_i} - \overline{E_0}\right) \pm l \qquad (i=1)$$

where, $\overline{E_i}$: The average value of the set of evaluated values read under test
environment humidity

$\overline{E_0}$: The average value of the set of evaluated values read under reference
humidity

l : It represents the width of the error, determined by Annex 2 Table 1

b)   Effect on the evaluated value

n-number of dosimeters which were bleached/annealed are prepared. The dosimeters are irradiated with test dose from Table 17 by γ-ray. The reader is placed under the influence of the test environmental humidity or the reference environmental humidity for 24 hours. After 24 hours while maintaining the environmental humidity conditions, read n number of dosimeters that are exposed as test dose. $\overline{E_i}$ is the average evaluated

value under the test environmental humidity conditions while $\overline{E_0}$ is the average evaluated values under the reference environmental humidity conditions. The variation of the evaluated values can be obtained by using following equation.

$$0.9 \leqq \frac{\overline{E_i}}{\overline{E_0}} \pm l \leqq 1.1 \qquad (i=1)$$

where, $\quad \overline{E_i}$: The average value of the set of evaluated values read under test environment humidity

$\overline{E_0}$: The average value of the set of evaluated values read under reference environment humidity

l : It represents the width of the error, determined by Annex 2 Table 1

Table 16   Conditions for stability test of the reader with respect to humidity

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Environmental monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
Test dose	2 mSv	0.2 mSv	0.2 mGy
Test environment humidity	More than 80% (24 hours or more)		
Reference environment humidity	50% or less (24 hours or more.)		

7.18   Stability of the reader to light

7.18.1   Performance

The stability of the reader to light, when tested by method 7.18.2, the acceptable range of variations in the background of the reader shall be within 0.2 times the detection limit specified in 7.8.

7.18.2   Test method

It is important to note that dosimeters shall not be inserted in the reader while doing this test. Light is irradiated to the reader under the conditions shown in Table 18 and is read n number of times. The average value is obtained and is indicated as $\overline{E_i}$. Next, the reader is read n number of times while under the conditions in a dark room. The average value is obtained and is indicated as $\overline{E_0}$. The variations in the background of the reader is obtained using the following equation.

$$\left(\overline{E_i} - \overline{E_0}\right) \pm l \qquad (i=1)$$

where, $\quad l$: It represents the width of the error, determined by Annex 2 Table 1

Table 17   Conditions for stability test of the reader with respect to light

Item	Conditions		
	Personal monitoring	Work place area/environment monitoring	Personal monitoring
Target dose	personal dose equivalent $H_p(10)$	ambient dose equivalent $H^*(10)$	air Kerma (K_a)
To the reader light irradiation test conditions	Xenon discharge lamp, using an ultra-high pressure mercury lamp or daylight fluorescent lamp. Light below a wavelength of 300 nm is filtered out, irradiated with light 3 klx in front of the reader		

8. INSPECTION

8.1 Standard inspection

Standard inspection of the following items were tested by chapter 7 provisions. It has to conform with chapter 7 provisions in order to pass. i.e.

a) Variations in the evaluated value

b) Reproducibility of the evaluated value

c) Dose linearity

d) Photon energy characteristics of the evaluated value

e) β-ray energy characteristics of the evaluated value

f) Angular dependence

g) Fading

h) Lower detection limit

i) Residual dose

j) Stability of the dosimeter to light

k) Stability of the dosimeter to temperature

l) Stability of the dosimeter to humidity

m) Stability of the dosimeter when dropped

n) Reusability

o) Stability of reader to variations in the power supply voltage

p) The stability of the reader to temperature

q) The stability of the reader to humidity

r) The stability of the reader to the light

8.2 Acceptance Inspection

8.2.1 Dosimeter

Dosimeter acceptance inspections for the conformance to chapter 7 provisions, is passed if it conforms to the chapter 7 provisions. However, the inspection is done by sampling. The number of dosimeters used for inspection is determined in accordance with consultations and agreements between the parties involved.

8.2.2 Reader

Reader acceptance inspection of the following items shall also confrom to chapter 7 provisions. The reader passes after tests are done and the reader conforms with the chapter 7 provisions.

9. Labels

9.1 Labels on the dosimeter

The dosimeter shall be marked with the following items. However, if it is difficult to place a label on the dosimeter, the label may be placed on the packaging of the dosimeter.

a) Type of dosimeter (by the manufacturer.)

b) Serial number

c) Manufacturer's name or its abbreviation

d) Dosimeters for personal monitoring using optically stimulated luminescence dose measuring device, need to indicate the front side of the dosimeter and the oppisite side which touches the surface of the person using the dosimeter. However, an exception is made for the dosimeters that does not need to define the front side.

9.2 Labels on the packaging of the dosimeter

The packaging of dosimeters shall be marked with the following items.

a) Name

b) Type of dosimeter (by the manufacturer.)

c) Serial number

d) Manufacturer's name or its abbreviation

9.3 Labels on the reader

The reader, shall be marked with the following items.

a) Name

b) Type of reader (by the manufacturer)

c) Production date or its abbreviation

d) Serial number

e) Manufacturer's name or its abbreviation

f) Rated voltage and rated frequency of the reader

10. Instruction manual

In optically stimulated luminescence dosimetry systems, it shall be accompanied by a manual that describe at least the following contents.

a) Handling of the dosimeter (personal, including a description of the type of work place area/environment.)

b) Energy characteristics of the dosimeter

c) Angular dependence of the dosimeter (Angular dependence with respect to X-ray or γ-ray etc.)

d) Method of wearing the dosimeter

e) Mass and dimensions of the dosimeter

f) Handling of the reader (personal, including a description of the type of the work place area/environment.)

g) Mass and dimensions of the reader

h) Usage Guidelines

Annex 1 (provisions) dose equivalent conversion factor

Annex 1 Table 1. personal dose equivalent $H_p(10)$ conversion factor $\left(f_{p10}\right)$

Photon energy or effective energy (¹) MeV	Conversion factor $\left(f_{p10}\right)$ (²) Sv/Gy
0.010	0.009
0.0125	0.098
0.015	0.264
0.0175	0.445
0.020	0.611
0.025	0.883
0.030	1.112
0.040	1.490
0.045	1.644
0.05	1.766
0.06	1.892
0.08	1.903
0.10	1.811
0.125	1.696
0.15	1.607
0.20	1.492
0.30	1.369
0.40	1.300
0.50	1.256
0.60	1.226
0.66(³)	1.212
0.80	1.190
1.0	1.167
1.25(⁴)	1.149
1.5	1.139
3.0	1.117
6.0	1.109
10.0	1.111

note (¹) The energy of X-ray and γ-rays in the case of a single photon energy. It is the effective energy when the photon energy does not have single energy. If there is no corresponding energy, it is determined by interpolation method.

(²) Personal dose equivalent - ICRU tissue equivalent phantom H_p from air Kerma , a conversion factor to the slab(10,0°). In the Table, it represents Hp, slab(10,0°) as Hp (10).

(³) The energy of ^{137}Cs gamma rays.

(⁴) Energy corresponding to the equivalent conversion factor of [60]Co γ-ray.

This reference table was based on ICRP Publication74.

Annex 1 Table 2 personal dose equivalent $H_p(0.07)$ conversion factor ($f_{p0.07}$)

Photon energy or effective energy ([1]) MeV	Conversion factor $(f_{p0.07})$ ([5]) Sv/Gy
0.005	0.750
0.010	0.947
0.015	0.981
0.020	1.045
0.025	1.130
0.030	1.230
0.040	1.444
0.045	1.546
0.050	1.632
0.060	1.716
0.080	1.732
0.10	1.669
0.15	1.518
0.20	1.432
0.30	1.336
0.40	1.280
0.50	1.244
0.60	1.220
0.66([3])	1.209
0.80	1.189
1.0	1.173

note([1]) and ([3]) is, See note of Annex 1 Table 1

([5]) Personal dose equivalent -ICRU tissue equivalent phantom Hp from air Kerma, a conversion factor to the $_{slab}(0.07,0°$).   In the Table, It represents Hp, $H_p(0.07)$ as Hp (0.07)

This reference table was based on ICRP Publication74.

Annex 1 Table 3. ambient dose equivalent $H{*}(10)$ conversion factor (f^{*}_{10})

Photon energy or effective energy ([1]) MeV	Conversion factor (f^{*}_{10}) ([6]) Sv/Gy
0.010	0.008
0.015	0.26
0.020	0.61
0.030	1.10
0.040	1.47
0.050	1.67
0.060	1.74
0.080	1.72
0.10	1.65
0.15	1.49
0.20	1.40
0.30	1.31
0.40	1.26
0.50	1.23
0.60	1.21
0.66([3])	1.20
0.80	1.19
1.0	1.17
1.25([4])	1.16
1.5	1.15
2.0	1.14
3.0	1.13
4.0	1.12
5.0	1.11
6.0	1.11
8.0	1.11
10	1.10

Note ([1]), ([3]) and ([4]) is, see note of Annex 1 Table 1

([6]) Conversion factor of ambient dose to the equivalent H * (10) of the depth of 10 mm from the air Kerma.

This reference table was based on ICRP Publication74.

Annex 1 Table 4. directional dose equivalent H'(0,07) conversion factor ($f'_{0.07}$)

Photon energy or effective energy (^{1}) MeV	Conversion factor ($f'_{0.07}$) (^{7}) Sv/Gy
0.010	0.95
0.015	0.99
0.020	1.05
0.025	1.13
0.030	1.22
0.040	1.41
0.050	1.53
0.060	1.59
0.080	1.61
0.10	1.55
0.15	1.42
0.20	1.34
0.30	1.31
0.40	1.26
0.50	1.23
0.60	1.21
0.66(^{3})	1.20
0.80	1.19
1.0	1.17
1.25(^{4})	1.16
1.5	1.15
2.0	1.14
3.0	1.13
4.0	1.12
5.0	1.11
6.0	1.11
8.0	1.11
10	1.10

Note (^{1}), (^{3}) and (^{4}) is, see note of Annex 1 Table 1

(^{7}) The conversion factor to the ambient dose equivalent H'(0.07) of depth 0.07 mm from the air Kerma.

This reference table was based on ICRP Publication74.

Annex 2 Method for calculating the error width l

1) **Scope of application**

This annex defines the method of calculating the width l of error in each calculation formula of chapter 7.

2) **Method of calculation**

Calculation of the width error l.

Annex 2 Table 1.

Test item number	The form of the equation	Method of calculating the l
7.3.2 **7.4.2** **7.5.2** **7.6.2** **7.9.2** **7.10.2** **7.11.2** **7.12.2** **7.13.2** **7.14.2** **7.15.2** **7.16.2 b)** **7.17.2 b)**	$\dfrac{\bar{x}_2}{\bar{x}_1} \pm l$	$l_1 = \dfrac{t_{n1}}{\sqrt{n_1}} S_1$, $l_2 = \dfrac{t_{n2}}{\sqrt{n_2}} S_2$ $l = \dfrac{\bar{x}_2}{\bar{x}_1} \sqrt{\left(\dfrac{l_1}{\bar{x}_1}\right)^2 + \left(\dfrac{l_2}{\bar{x}_2}\right)^2}$
7.7.2	$\dfrac{\bar{x}_2 - \bar{x}_3}{\bar{x}_1} \pm l$	$l_1 = \dfrac{t_{n1}}{\sqrt{n_1}} S_1$, $l_2 = \dfrac{t_{n2}}{\sqrt{n_2}} S_2$, $l_3 = \dfrac{t_{n3}}{\sqrt{n_3}} S_3$ $l = \dfrac{\bar{x}_2 - \bar{x}_3}{\bar{x}_1} \sqrt{\left(\dfrac{l_1}{\bar{x}_1}\right)^2 + \dfrac{l_2^2 + l_3^2}{(\bar{x}_2 - \bar{x}_3)^2}}$
7.16.2 a) **7.17.2 a)** **7.18.2**	$(\bar{x}_1 - \bar{x}_2) \pm l$	$l_1 = \dfrac{t_{n1}}{\sqrt{n_1}} S_1$, $l_2 = \dfrac{t_{n2}}{\sqrt{n_2}} S_2$ $l = \sqrt{l_1^2 + l_2^2}$

Remarks:

$\bar{x}_i$: i th average value within evaluated formula

n_i : The number of data used in the average

t_{ni} : In t values for n_i, determined by Annex 2 Table 2.

S_i : estimate of the standard deviation.

$$S_i = \sqrt{\dfrac{\sum_{j=1}^{n}\left(x_{ij} - \bar{x}_i\right)^2}{n-1}}$$

Annex 2 Table 2 t_n values for n_i

n	t_n
2	12.71
3	4.30
4	3.18
5	2.78
6	2.57
7	2.45
8	2.37
9	2.31
10	2.26
11~15	2.15
16~20	2.09
21~25	2.06
26~30	2.05
31~40	2.02
41~60	2.00
61~120	1.98
121	1.96

JIS Z 4339 : 0000

Optically stimulated luminescence dosimetry systems
Explanation (not included in this standard)

この解説は，本体及び附属書に規定した事柄，参考に記載した事柄，並びにこれらに関連した事柄を説明するもので，規格の一部ではない。

この解説は，財団法人日本規格協会が編集・発行するものであり，この解説に関する問合せは，財団法人日本規格協会へお願いします。

1) 制定の趣旨 従来まで個人線量計としては，フィルムバッジ（**JIS Z 4301**，**JIS Z 4302** 及び **JIS Z 4323**）が広く使用されてきた。しかし，今日では，その現像に伴う廃液などの環境問題に配慮し，更に個人モニタリング用だけでなく環境モニタリング用としても対応が可能な，より性能の高い個人線量計が必要となった。

放射線検出法の一つである Optically Stimulated Luminescence（光刺激ルミネセンス）を線量測定に応用した線量計は，近年急速に開発が進められた個人線量計の一つであり，現在，世界各国でさまざまな研究が行われており，既に実用も開始されている。光刺激ルミネセンス線量計は，フィルムバッジと比較して，測定範囲が広いうえに精度が良く，繰返し測定が可能であり，更に反復使用が可能であるという利点がある。また，放射線検出素子には耐水性の無機化合物の粉末を用いているため，軽量で耐久性に優れている。測定原理としては，現在利用されている熱ルミネセンス線量計**(JIS Z 4320)**及び蛍光ガラス線量計**(JIS Z 4314)**と類似しているが，大きな違いは測定及び再生処理に高温加熱を要しないという点である。測定は，LED 光やレーザ光を用いた可視光の照射による励起で簡単に行うことができ，また，再生処理も蛍光灯の光を当てるだけで可能である。ただし，使用時はフィルム線量計と同様に素子を遮光状態にしなければならない。

光刺激ルミネセンス線量計が，今後，国内において導入された場合，個人線量計の一つとして広く普及していくものと考えられる。このような状況から，光刺激ルミネセンス線量計測装置の **JIS** について新規に制定する運びとなった。

2) 制定の経緯 放射線従事者の個人被ばく線量測定機は，**JIS Z 4323**（広範囲用フィルムバッジ）などで規定されているフィルムバッジによって評価されている。近年，放射線従事者の増加及び測定機器の多様化が進み，測定感度及び制度の高い測定器の要望が要求されている。この線量計は，外部被ばくの測定のための個人線量計（放射線測定器）としての **JIS** 化の要望が高い。また，ICRP（ICRP とは，国際放射線防護委員会の略で我が国の法律の基礎となる勧告を定める委員会。）の '90 年勧告によって国内法令が改正され，2001 年 4 月に放射線障害防止関連法令などが施行された。これによって，この **JIS** もその内容に合わせ策定となった。

3) 審議中に問題となった事項 審議中に問題となった事項は，次による。
1)) 当初は，個人モニタリング用と作業環境モニタリング用についての規格であったが，光刺激ルミネ

センス線量計測装置が環境モニタリング用についても十分に対応できる性能をもっているため，これについても規定することとなった。

2)) 光刺激ルミネセンス線量計測装置は，繰返し測定が可能であるが，特性上，同一線量計の測定を重ねるごとにその値は減少していく。これについての規格の制定を検討したが，現在規定されている試験においては初回の測定値が評価の対象となっており，これらの試験で通常の使用に対して十分に性能評価できるため，複数回の測定における性能の規格化については見送ることとした。

3)) 現在，光刺激ルミネセンス線量計測装置に関する国際規格はないが，今後，制定される可能性があると考えられる。そこで，国際規格(IEC)のある熱ルミネセンス線量計測装置の **JIS** が，その **IEC** に規格の表現を合わせる形式をとって改正を行ったことから，光刺激ルミネセンス線量計測装置の **JIS** においてもその表現にならうこととした。特に誤差の表現については検討がなされたが，熱ルミネセンス線量計測装置の **JIS** の表現に統一することとした。

4)　適用範囲　この計測装置は，パッシブ形線量計であり，熱ルミネセンス線量計測装置と同様な機能をもっている。また，関連する放射線関係法令に合わせ，"個人""作業環境""環境"用モニタリング線量計測装置それぞれを規定してある。

5)　規定項目の内容

a)　　光刺激ルミネセンス［本体 **3.a)**］　実用化されている，炭素添加 α 酸化アルミニウム(α-Al$_2$O$_3$:C)においての発光波長は青（420 nm）である。この発光波長は物質によって異なる。

b)　　光刺激ルミネセンス線量計測素子［本体 **3.b)**］　実用化されている素子は，α-Al$_2$O$_3$:C の粉末（粒径 35 〜65 μm）を透明のポリエステル樹脂の表面に 100 μm の厚さに塗布したフィルム状のものが用いられており，線量計自体の吸収による誤差が小さいため，ベータ線，エネルギーの低い X 線など透過力の弱い放射線に対して特に精度が高い。また，素子が α-Al$_2$O$_3$:C，ポリエステルなどの原子番号の低い物質だけで構成され，天然の放射性同位元素を含みやすい原子番号の高い物質を含まないため，素子自身からの放射線量も少なく，環境線量などの小線量測定にも適している。

c)　　リーダ［本体 **3.e)**］　α-Al$_2$O$_3$:C を用いた線量計では，刺激光として超高輝度緑 LED（平均波長 525 nm）又は Laser（532 nm：緑）が用いられている。α-Al$_2$O$_3$:C の理想的な刺激光の波長は 420 nm であるが，刺激光とルミネセンスが同一波長ではルミネセンスが弁別できないため，ルミネセンスより 100 nm 長い波長の光を刺激光に用い，光学フィルタによってこれらの光を分離し，ルミネセンスだけをパルス形光電子増倍管で計測している。

d)　　再生処理［本体 **3.j)**］　α-Al$_2$O$_3$:C は高熱（600 ℃）によって線量計の初期化が可能である。しかしながら，青（420 nm）の光を長時間（明るさによって照射時間は変化する。）照射することによって，容易に初期化ができるので，こちらの方がより実用的である。太陽光及び人工光源（蛍光灯など）においても初期化は可能であるが，α-Al$_2$O$_3$:C は製造ロットによっては紫外線によってエネルギーを蓄積する場合があるため，注意が必要である。

e)　　初期フェーディング［本体 **3.n)**］　α-Al$_2$O$_3$:C においては，初期フェーディングは認められないが，現在開発中の幾つかの異なった素材においては初期フェーディングが認められているため規格の中に定めた。

f)　線量計 ［本体 5.b)］　実用化されている α-Al$_2$O$_3$:C を検出素材に用いた線量計は，素子とホルダとを一体化させたものが用いられている。エネルギー補償用のフィルタとしては，すず（厚さ 0.5 mm），銅（厚さ 0.2 mm）の二つをもち，適用範囲に定めた線種及びエネルギーを測定可能としている。

g)　ファントム ［本体 6.1.3］　ファントムを用いる試験項目を実施する場合には，**JIS Z 4331**（X 線及び γ 線個人線量計校正用ファントム）に規定されているファントム(40×40×15 cm)を用いる。この規格には規定していないが，照射を行う際には，ファントム全体が入る大きさの照射野を確保し，ファントム表面全体がほぼ平行なビームで照射される必要がある。このためには，線源とファントム表面までの距離とが約 2 m 以上であることが望ましい［**JIS Z 4511**（照射線量測定器及び線量当量測定器の校正方法）参照］。

h)　評価値の方向特性 ［本体 7.6］　個人モニタリング用光刺激ルミネセンス線量計の方向特性試験において，放射線の入射方向を変える方法としては，校正装置の構造上の制約を考え，線源を固定してファントムを回転させるものとする。回転軸は光刺激ルミネセンス線量計内の素子の位置としなければならない。また，ファントムを水平方向に回転させることは容易であるが，上下方向の回転については，ファントムの固定など実際上かなり困難である。そのため光刺激ルミネセンス線量計を横向きに 90°回転させてファントムに設置することによって，ファントムの水平方向の回転を上下方向の回転とみなして試験を行う。

6)　懸案事項

a)　光刺激ルミネセンス線量計の繰返し読取りについて
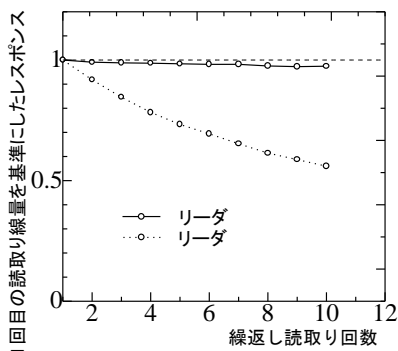
解説図 1　繰返し読取りの線量減少率

光刺激ルミネセンス線量計は刺激光の強度を調節することによって，繰返し測定が可能である。このことによって線量計又はリーダに異常があった場合，線量計を再度リーダで読み取ることによって，線量値を取得できる。しかし，繰返し測定を行うたびに読取値は指数関数的に減少する。

解説図 1 は刺激光源の異なったリーダによって同一線量を照射した線量計の繰返し読取り線量を，1 回目の読取値を基準とした相対値で表したグラフである。A リーダは暗い光源を用いている。このため 10 回の繰返し読取りによって 2.5 ％程度の読取り量の減少である。B リーダは非常に明るい光源を用いており 10 回の繰返し読取りで約 50 ％の減少が起きている。繰返し読取り性能で見る限り A リーダは優れているが，刺激光の明るさとルミネセンスの量とは比例関係にあるため，A リーダでは低線量の測定ができない。

B リーダの減衰特性を式で表すと，

$$y = a\left(1 - \frac{b}{a}\ln x\right)$$

と表記できる。b /a は読み取り方式と刺激光の強度で決まる減衰率であり，刺激光の量が一定であるときは，線質・線量にかかわらずほぼ同様な値を示す。繰返し測定の規格において，A リーダの場合，複数の繰返し測定による線量の減少は無視できるが，B リーダの場合は減少を無視できないので，リーダに減衰率を表記することによって規格化が可能であると思われる。

現時点では，繰返し測定を規格化するための技術的裏付けが十分とはいえず，次回の改正の際に検討

を行いたい。

7)　引用に関する事項　該当なし。

8)　特許権などに関する事項　該当なし。

9)　その他　該当なし。

10)　原案作成委員会の構成表　原案作成委員会の構成表を次に示す。

JIS Z 4339 改正原案作成委員会　構成表

		氏名	所属
（委員長）		濱　田　達　二	社団法人日本アイソトープ協会
（委員）		石　田　正　美	文部科学省科学技術・学術政策局原子力安全課
		金　澤　　　晃	経済産業省原子力安全保安院原子力保安管理課
		上　田　博　三	厚生労働省労働基準局安全衛生部労働衛生課
		山　村　修　蔵	財団法人日本規格協会
	○	高　田　信　久	産業技術総合研究所放射線標準研究室
	○	丸　山　隆　司	放射線医学総合研究所
（分科会委員長）	○	加　藤　　　朗	国立公衆衛生院
	○	村　上　博　幸	日本原子力研究所東海研究所保健物理部
	○	辻　村　憲　雄	核燃料サイクル開発機構東海事業所放射線安全部
	○	川　瀬　弘　二	東京電力株式会社原子力管理部
	○	村　松　邦　博	日本原子力発電株式会社発電管理室
	○	征　矢　郁　郎	三菱重工業株式会社原子力事業本部原子力技術部
	○	佐々木　幸　男	財団法人放射線計測協会
	○	草　間　経　二	社団法人日本アイソトープ協会
	○	宮　野　敬　治	財団法人日本分析センター
	○	空　増　　　昇	松下電器株式会社電子機器事業部
	○	三　宅　周　作	極光株式会社
	○	寿　籐　紀　道	株式会社千代田テクノル大洗研究所
	○	Ikuo Kobayashi	Nagase Landauer Ltd.
	○	吉　田　賢　一	産業科学株式会社営業技術部
	○	釜　田　敏　光	ポニー工業株式会社技術部
	○	福　田　光　道	個人線量測定機関協議会
	○	渡　邉　道　彦	株式会社シー・イー・シー
（オブザーバー）		龝　山　貞　治	経済産業省産業技術環境局

（事務局）　　　　　　　久保野　隆　一　　　社団法人日本電気計測器工業会
　　　　　　　　　　　　備考　〇印は，分科会委員を示す。
　　　　　　　　　　　　　　　　　　（文責　JIS Z 4339 改正原案作成委員会）

JAPANESE INDUSTRIAL STANDARD

Optically stimulated luminescence dosimetry systems

JIS Z 4339 : 0000

（JEMIMA／JSA）

Established 0000-00-00

Investigated by

Japanese Industrial Standards Committee

Published by

Japanese Standards Association

定価：本体 **0,000** 円（税別）