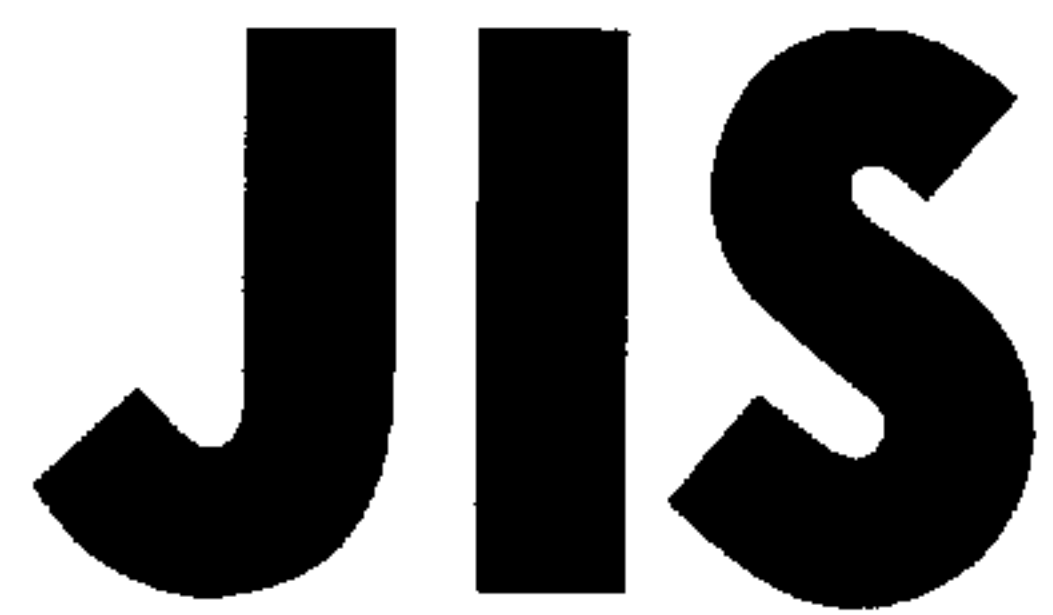




JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS Z 4323 : 1997

Universal film badges

ICS 17.240

Descriptors : X-rays, gamma-radiation, human body, radiology apparatus (medical),
medical radiography, dosimeters, exposure-rate meters, radiography,
radiographic film

Reference number : JIS Z 4323 : 1997 (E)

Z 4323: 1997

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of International Trade and Industry through deliberations at Japanese Industrial Standards Committee in accordance with the Industrial Standardization Law:

Date of Establishment: 1974-02-01

Date of Revision: 1997-07-20

Date of Public Notice in Official Gazette: 1997-07-22

Investigated by: Japanese Industrial Standards Committee
Divisional Council on Medical and Safety

JIS Z 4323: 1997, First English edition published in 1998-03

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

© JSA 1998

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

Universal film badges

Introduction This Standard is a Japanese Industrial Standard which is established without any modification of the technical content of **ISO 1757** *Personal photographic doseimeters*, published as the first edition in 1980.

1 Scope This Japanese Industrial Standard specifies the universal film badges for measuring the 1 cm dose equivalent, 3 mm dose equivalent and 70 μm dose equivalent which a person received from outside of his body by X-ray of 20 keV to 3 MeV in effective energy or γ -ray and thermal neutrons of 20 keV to 3 MeV in photon energy, and 70 μm dose equivalent which a person received from outside of his body by β -ray of 0.5 MeV to 3 MeV in residual maximum energy, and the methods for calculating those dose equivalents by using these film badges.

Remarks 1 The method for judging performance in Annex 1, the method for calculating dose equivalent in Annex 2 and the method for measuring the response to β -ray in Annex 3 are specified respectively.

2 The normative references to this Standard are as follows :

JIS K 7559 *Universal badge films*

JIS K 7652 *Photography-Density measurements-Part 2 : Geometric conditions for transmission density*

JIS K 7653 *Photography - Density measurements - Part 3 : Spectra conditions*

JIS Z 4001 *Glossary of terms used in nuclear energy*

JIS Z 4331 *Calibration phantom for X-, γ - and β -ray personal doseimeters*

JIS Z 4332 *General requirements for personal X-ray and γ -ray doseimeters*

JIS Z 4511 *Methods of calibration for exposure meters and dose-equivalent meters*

JIS Z 8103 *Glossary of terms used in instrumentation*

JIS Z 8401 *Rules for rounding off of numerical values*

3 The International Standard corresponding to this Standard is as follows :

ISO 1757 *Personal photographic doseimeters*

2 Definitions For the main terms used in this Standard, the definitions in **JIS Z 4001**, **JIS Z 4332**, **JIS Z 4511** and **JIS Z 8103** apply, and the rest of the terms are as follows.

Remarks 1 Tissue absorbed dose or tissue absorbed dose rate is described as "tissue absorbed dose (rate)" in this Standard.

2 Dose equivalent or dose equivalent rate is described as "dose equivalent (rate)" in this Standard.

- (1) **residual maximum energy** Energy corresponding to the maximum range of β -ray in the reference point of calibration.
- (2) **measured value** A dose equivalent calculated from the film badge before rounding off.
- (3) **reference value** The testing dose specified in the testing method as reference.
- (4) **error (ε)** The ratio of the difference between the mean value of measured values ($\bar{X}$) and the reference value (H_0) to the reference value.

$$\varepsilon = \frac{|\bar{X} - H_0|}{H_0}$$

- (5) **coefficient of variation (C)** The ratio of the standard deviation (S) of n measured values (X_i) to the mean value ($\bar{X}$) of measured values.

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

- (6) **response (R)** The ratio of mean value ($\bar{X}$) of measured values to the reference value (H_0).

$$R = \frac{\bar{X}}{H_0}$$

- (7) **reference γ -ray** The specific γ -ray to obtain the dose characteristics.
- (8) **relative response of γ -ray (RR_γ)** The ratio of response of X γ -ray having optional energy (R) to the response of reference γ -ray (R_γ).

$$RR_\gamma = \frac{R}{R_\gamma}$$

- (9) **badge film** That having packed high, medium and low sensitivity films painted with photographic emulsions having appropriate sensitivity to radiation and different sensitivity in one unit or that having the equivalent performance.
- (10) **control film** The badge film to be used to remove errors caused by foggings of natural radiation and photographic density of film characteristic.
- (11) **filter** A filtering plate having material quality, thickness and size to give photographic density suitable for badge film for calculating dose equivalent.
- (12) **γ -ray reference filter** A filter specially selected to determine the dose characteristic of γ -ray out of the various filters set in the badge case.
- (13) **thermal neutrons reference filter** A filter capable of obtaining appropriate film sensitivity to thermal neutrons in the filter set in the badge case.

- (14) **radioisotope neutron source** A radiation source generating neutrons by nuclear reaction such as $^{241}\text{Am}-\text{Be}$, or a radiation source generating neutrons by spontaneous fission such as ^{252}Cf .
- (15) **filter position** A position on the badge film capable of observing the effect of filter.
- (16) **apparent dose** A dose corresponding to the photographic density at the filter position on the dose characteristic curve.
- (17) **net apparent dose** A dose obtained from apparent dose at filter position subtracted with apparent dose of control film.
- (18) **dose equivalent calculating formula** The calculating formula to calculate the dose equivalent from net apparent dose at each filter position of the badge film.
- (19) **proportionality test** The test to confirm that the response corresponding to 1 cm dose equivalent is constant.
- (20) **using period** In the case of continuously managing the personal dose, the period decided with the performance of film badge and consideration on the management. This period is defined by the period from the day when the film badge is exchanged to the day before next exchange day. It is not taken into account whether radioactive work is done or not during this period.
- (21) **dose characteristic** A relationship between photographic density at the filter position of γ -ray reference filter (hereafter called γ -ray reference filter position) and the exposure of reference γ -ray.
- (22) **γ -ray relative sensitivity (RS_γ)** A value obtained by dividing the ratio of net apparent dose in the case of irradiating X· γ -ray to the exposure (N) by the ratio of net apparent dose in the case of irradiating reference γ -ray to the exposure (N_γ).

$$RS_\gamma = \frac{N}{N_\gamma}$$

- (23) **film energy characteristic** A relation between energy of X· γ -ray and γ -ray relative sensitivity.
- (24) **fading** The phenomenon that photographic density after development is less than the photographic density immediately after irradiation because of variation by time of latent image made in the film emulsion.
- (25) **thermal neutron sensitivity** The ratio of difference between net apparent dose at the filter position of reference filter of thermal neutron (hereafter called thermal neutron reference filter position) and the net apparent dose at the γ -ray reference filter position to quantity of thermal neutron irradiated.
- (26) **film sensitivity to thermal neutron** The ratio of net apparent dose corresponding to density given by irradiation of thermal neutrons to quantity of thermal neutron irradiated.
- (27) **relative response of β -ray (RR_β)** The ratio of response of β -ray having optional energy (R) to the response of β -ray of 2.2 MeV (^{90}Sr - ^{90}Y) in residual maximum energy (R_β).

$$RR_{\beta} = \frac{R}{R_{\beta}}$$

- (28) **relative sensitivity of β -ray (RS_{β})** A value obtained by dividing the ratio of net apparent dose in the case of irradiating β -ray to the exposure (N) by the ratio of net apparent dose in the case of irradiating β -ray of 2.2 MeV (^{90}Sr - ^{90}Y) in residual maximum energy to the exposure (N_{β}).

$$RS_{\beta} = \frac{N}{N_{\beta}}$$

- (29) **reference of tissue absorbed dose (rate)** 70 μm tissue absorbed dose (rate) of β -ray at the reference point of calibration.
- (30) **reference of β -ray dose equivalent** 70 μm dose equivalent (rate) of β -ray at the reference point of calibration, obtained by multiplying dose equivalent conversion factor, etc. with the reference of tissue absorbance dose (rate).
- (31) **calibration of β -ray film badge** To obtain response of film badge from the relation between the reference of β -ray dose equivalent and the measured values.
- (32) **reference calibration** To set the reference of tissue absorbed dose (rate).
- (33) **tissue equivalent material** The material such as polyethylene-terephthalate, polymetacryl-acid-methyl, polystyrene.
- (34) **absorption plate of measurement of residual range** A thin plate made of tissue equivalent material placed immediately before β -ray measuring instrument having thin window set at the calibration position, and used for determining the residual range by measuring β -ray attenuation curve.
- (35) **radiation quality control filter** A filter made of the low atomic number materials used for setting the residual maximum energy at the reference point of calibration to an appropriate value.

3 Performance

3.1 Error and coefficient of variation of measured values

3.1.1 **X· γ -ray** When the film is tested according to 6.2.2 (1), its error and coefficient of variation of the measured values shall be as follows :

- (1) About the high sensitivity film, as for the error generated by irradiation of 0.4 mSv, the response corresponding to the error shall be in the range of 1 ± 0.3 at reliability of 95 % and the coefficient of variation shall be 0.07 or under, and as for the error generated by irradiation of 4.0 mSv, the response corresponding to error shall be in the range of 1 ± 0.1 with reliability of 95 % and the coefficient of variation shall be 0.05 or under.
- (2) About the medium sensitivity film, as for the error generated by irradiation of 30 mSv, the response corresponding to the error shall be in the range of 1 ± 0.1 with reliability of 95 % and the coefficient of variation shall be 0.07 or under.

- (3) About the low sensitivity film, as for the error generated by irradiation of 200 mSv, the response corresponding to the error shall be in the range of 1 ± 0.1 with reliability of 95 % and the coefficient of variation shall be 0.07 or under.

3.1.2 β -ray When the film is tested according to 6.2.2 (2), as for the error generated by irradiation of β -ray of 4.0 mSv, the response corresponding to the error shall be in the range of 1 ± 0.15 with reliability of 95 % and the coefficient of variation shall be 0.07 or under.

3.1.3 Thermal neutrons When the film is tested according to 6.2.2 (3), as for the error generated by irradiation of thermal neutrons of 0.4 mSv, the response corresponding to the error shall be in the range of 1 ± 0.3 with reliability of 95 % and the coefficient of variation shall be 0.1 or under.

3.2 Variation characteristic by time of measured values When the film is tested according to 6.2.3, the variation rate by time for 30 days of measured values shall be 0.15 or under with reliability of 95 % for that stored at 20 ± 5 °C, and 0.25 or under for that stored at 40^{+5}_0 °C.

3.3 Proportionality of measured values

3.3.1 X· γ -ray When the film is tested according to 6.2.4 (1), the proportionality of measured values shall be as follows :

- (1) For high sensitivity films, the response to every dose equivalent is in the range of 1 ± 0.15 with reliability of 95 % to the response of 4.0 mSv.
- (2) For medium sensitivity films, the response to every dose equivalent is in the range of 1 ± 0.15 with reliability of 95 % to the response of 30 mSv.
- (3) For low sensitivity films, the response to every dose equivalent is in the range of 1 ± 0.15 with reliability of 95 % to the response of 200 mSv.

3.3.2 β -ray When the film is tested according to 6.2.4 (2), the proportionality of measured values shall be as follows :

- (1) For high sensitivity films, the response to every dose equivalent is in the range of 1 ± 0.25 with reliability of 95 % to the response of 4.0 mSv.
- (2) For medium sensitivity films, the response to every dose equivalent is in the range of 1 ± 0.25 with reliability of 95 % to the response of 30 mSv.

3.4 Energy characteristic

3.4.1 X· γ -ray When the film is tested according to 6.2.5 (1), the relative response at each energy of X· γ -ray for high, medium and low sensitivity films shall be in the range of 1 ± 0.3 with reliability of 95 %.

3.4.2 β -ray When the film is tested according to 6.2.5 (2), the relative response at each residual maximum energy of β -ray for high and medium sensitivity films shall be in the range of 1 ± 0.35 with reliability of 95 %.

3.5 Directional characteristic of X- γ -ray When the film is tested according to 6.2.6, the response in every angle for high sensitivity film shall be in the range of 1 ± 0.3 with reliability of 95 % to the response in 0° direction.

3.6 Stability for humidity When the film is tested according to 6.2.7, the response of relative humidity of 90 % or over for high, medium and low sensitivity films shall be in the range of 1 ± 0.15 with reliability of 95 % to the response of relative humidity of 50 % or under.

3.7 Stability for light When the film is tested according to 6.2.8, the difference between photographic density of the film irradiated by light and that of the film not irradiated by light shall be 0.02 or under with reliability of 95 %.

4 Structure

4.1 Film badges The film badges shall consist of a badge case and badge films.

4.2 Badge case The badge case shall consist of a part containing badge film and filter.

Further, the badge case may be attached with jig for equipment such as clip and the like.

4.3 Filter The filter shall be possessed appropriate characteristics for calculating dose equivalents of X-ray, γ -ray, thermal neutrons and β -ray.

5 Badge film The badge film shall be that complied with the specification of JIS K 7559 or that equivalent in performance thereto.

6 Tests

6.1 Test conditions

6.1.1 Common test conditions The common test conditions shall be in accordance with Table 1 unless specially specified in test methods of 6.2.

Table 1 Common test conditions

Item		Conditions
Ambient temperature	°C	20 ± 5
Relative humidity	%	60 ± 15
Atmospheric pressure	hPa	1013 ± 50
1 cm dose equivalent rate of test environment	$\mu\text{Sv/h}$	≤ 0.2

6.1.2 Calibrating apparatus and thermal neutron source The calibrating apparatus and thermal neutron source to be used for testing shall be as follows :

- (1) **X-ray calibration apparatus** The X-ray calibration apparatus shall be the X-ray irradiation apparatus of which exposure (rate) has been measured by the exposure (rate) measuring instrument having traceability to the exposure standard specified in JIS Z 4511.

The ratio (quality index) of the effective energy to the energy corresponding to the tube voltage shall be set at 0.6 or over.

- (2) **γ -ray calibration apparatus** The γ -ray calibration apparatus shall be ^{137}Cs or ^{60}Co γ irradiation apparatus of which exposure (rate) has been measured by the exposure (rate) measuring instrument having traceability to the exposure standard specified in JIS Z 4511, or the reference γ -ray source of ^{137}Cs or ^{60}Co .
- (3) **β -ray calibration apparatus** The β -ray calibration apparatus shall be the β -ray irradiation apparatus having traceability relating to 70 μm dose equivalent.
- (4) **Thermal neutron source** Thermal neutron source shall be an apparatus which a radioisotope neutron source or other neutron source is placed in a graphite pile or a similar modulator. And thermal neutron generated in the modulator shall be used. The traceability relating to fluence rate of thermal neutron shall be clear.

6.1.3 1 cm dose equivalent The 1 cm dose equivalent shall be determined by multiplying the exposure with conversion factor corresponding to energies of X- γ -ray given in Attached Table 1.

Also, the 1 cm dose equivalent for thermal neutron shall be determined by multiplying the thermal neutron fluence with conversion factor corresponding to thermal neutron given in Attached Table 4.

6.2 Test Methods

6.2.1 Test methods general The test methods general shall be as follow :

- (1) In case where the test is performed with a certain item out of test conditions changed, the other conditions shall be in the range given in Table 1.
- (2) The test dose shall be 1 cm dose equivalent in the case of X- γ -ray and thermal neutron and 70 μm dose equivalent in the case of β -ray, and shall be set in the range of 80 % to 120 % of the dose equivalent specified in each item, and the same quantity shall be set for each set.
- (3) X-ray energy shall be effective energy and β -ray energy shall be residual maximum energy, and the energy to be set at the time of irradiation shall be set in the range of 90 % to 110 % of energy specified by each item and the same energy shall be set for each set.
- (4) The tests of 6.2.2, 6.2.5 and 6.2.6 shall be performed under the condition where the film badge shall be arranged in front of the phantom specified in JIS Z 4331.

- (5) In the case where the film badge is arranged in the front of phantom, it is to be set in the range shown in Fig. 1.

Further, the distance between surface of phantom and the calibration point of film badge is optionally selected in the range of 1 cm to 3 cm and the setting error shall be ± 2 mm, and the same condition shall be kept through each test.

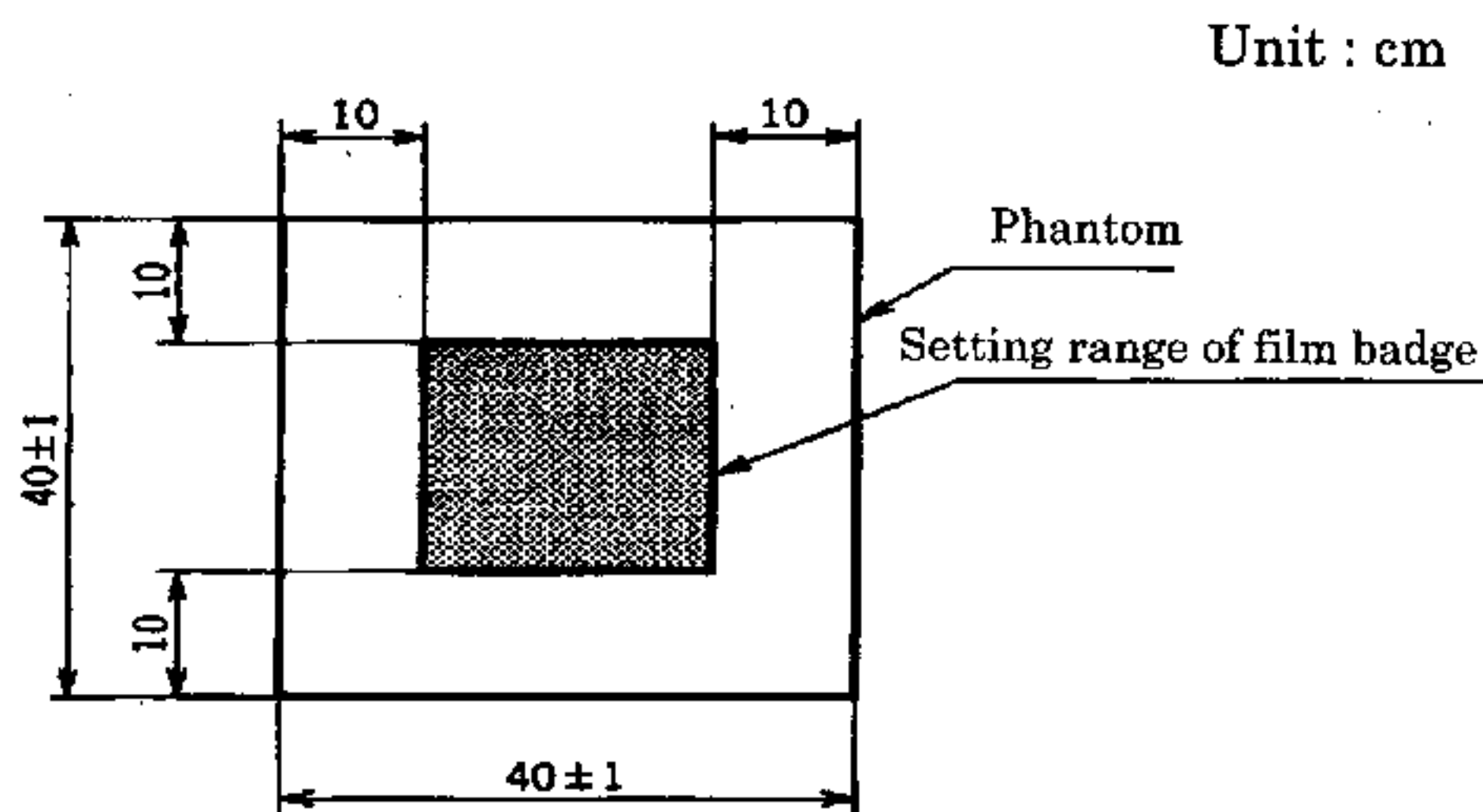


Fig. 1 Setting range of film badge on phantom

- (6) The test specified in 6.2.2 shall be performed, whenever the lot of badge film is varied. However, except the tests by β -ray and thermal neutron.
- (7) In each test method, the mean value, standard deviation of measured values and standard deviation relating to the mean value of measured values are to be obtained with the following formulae, excepting 6.2.8.
- (a) The mean value of measured values is obtained with the following formula.

$$\bar{X} = \frac{\sum_{i=1}^n X_i}{n}$$

where, $\bar{X}$: mean value of measured values (mSv)

X_i : i -th measured value (mSv)

n : number of measured values

- (b) The standard deviation of measured values is obtained with the following formula.

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (X_i - \bar{X})^2}$$

where, S : standard deviation of measured values (mSv)

X_i : i -th measured value (mSv)

$\bar{X}$: mean value of measured values (mSv)

n : number of measured values

- (c) The standard deviation relating to mean value of measured values is obtained with the following formula.

$$S_m = \frac{S}{\sqrt{n}}$$

Where, S_m : standard deviation relating to mean value of measured values (mSv)

S : standard deviation of measured values (mSv)

n : number of measured values

- (8) The calculating formula of dose equivalent relating to X· γ -ray shall be in accordance with 2 (1.3) of Annex 2 and the same formula is applied through all tests necessary for obtaining the measured values for each type of film badge.
- (9) The judgment method of performance shall be in accordance with Annex 1.
- (10) The calculating method of measured values shall be in accordance with Annex 2.
- (11) The measuring method of response relating to β -ray shall be in accordance with Annex 3.

6.2.2 Test of error in measured values and coefficient of variation

- (1) **X· γ -ray** Prepare 50 film badges consisting of badge film of the same lot. Take 10 pieces as one group, make 5 groups, and take as H₁ group, H₂ group, M group, L group and C group. Irradiate γ -ray of ¹³⁷Cs or ⁶⁰Co to each group as given in Table 2. However, take C group as control films and do not irradiate γ -ray.

Store the exposed badge films together with the control films for 3 days and then develop them. Calculate the measured values from the high sensitivity film for H₁ and H₂ groups, from medium sensitivity film for M group and from low sensitivity film for L group and obtain the response corresponding to error according to the following formula.

$$R_e = \varepsilon + 1 \dots\dots\dots (1)$$

where, R_e : response according to error

ε : error

Table 2 Dose equivalent for error test

Unit : mSv

Group	H ₁	H ₂	M	L
1 cm dose equivalent	0.4	4.0	30	200

- (2) **β -ray** Prepare 12 film badges consisting of badge film of the same lot. Take 6 pieces as one group, make 2 groups, and take as H group and C group. Irradiate 70 μ m dose equivalent of β -ray to 4.0 mSv to the film badges of H group. However, take C group as control films and do not irradiate β -ray.

Store the exposed badge films together with the control films for 3 days and then develop them. Calculate the measured values from the high sensitivity film for H group, obtain the response corresponding to error by the formula (1).

- (3) **Thermal neutrons** Prepare 6 film badges consisting of badge film of the same lot. Take 3 pieces as one group, make 2 groups, and take as H group and C group. Irradiate 1 cm dose equivalent of thermal neutrons to 0.4 mSv to the film badges of H group. However, take C group as control films and do not irradiate thermal neutrons.

Store the exposed badge films together with control films for 3 days and then develop them. Calculate the measured values from the high sensitivity film for H group, obtain the response corresponding to error by the formula (1).

6.2.3 Test of characteristic variation by time of measured values Prepare 40 film badges consisting of badge film of the same lot. Take 5 pieces as one set, make 8 sets and take two sets in each to make H group, M group, L group and C group. Irradiate γ -ray of ^{137}Cs or ^{60}Co to all film badges of H, M and L groups in accordance with Table 3. However, take the badge films of C group as control film for each storing number of days and do not irradiate γ -ray.

Store the exposed badge films together with control films at ambient temperature of $20 \pm 5^\circ\text{C}$ in accordance with Table 4. Furthermore, prepare 40 film badges consisting of badge films of the same lot mentioned above and after treating them with the same manner mentioned above, store these exposed film badges at ambient temperature of $40^{+5}_0^\circ\text{C}$ in accordance with Table 4.

After development, calculate measured values from high sensitivity film for H group and from medium sensitivity film for M group and from low sensitivity film for L group.

For respective film badges stored at ambient temperature of $20 \pm 5^\circ\text{C}$ and $40^{+5}_0^\circ\text{C}$, take the mean value of measuring values of set corresponding to storing days of 3 days as $(\bar{X}_0)$ and the mean value of measuring values of set corresponding to storing days of 33 days as $(\bar{X})$, and obtain the variation rate by time (R_t) with the following formula :

$$R_t = \frac{|\bar{X} - \bar{X}_0|}{\bar{X}_0}$$

Table 3 Dose equivalent for test of characteristic variation by time

Unit : mSv

Group	H	M	L
1 cm dose equivalent	4.0	30	200

Table 4 Storing number of days for test of characteristic variation by time
Unit : d

Set (common for each group)	1st	2nd
Number of storing days after irradiation till development	3	33

Remarks : In this Table, the 1st and 2nd sets are determined by optionally selecting one set in each from two sets constructing each group.

6.2.4 Proportionality test of measured values

- (1) **X- γ -ray** Prepare 100 film badges consisting of badge film of the same lot. Take 5 pieces as one set, prepare 20 sets and take 6 sets as H group, and 7 sets as M group and L group. Irradiate γ -ray of ^{137}Cs or ^{60}Co to each set of each group in accordance with Table 5. However, take 1 set of each group as control films and do not irradiate γ -ray.

Store the exposed badge films together with control films for 3 days and then develop them. Calculate the measured values from the high sensitivity film for H group, from medium sensitivity film for M group and from low sensitivity film for L group. Obtain the ratio of the response of 4.0 mSv for high sensitivity film, 30 mSv for medium sensitivity film and 200 mSv for low sensitivity film to the response of each dose equivalent.

Table 5 Dose equivalent of proportionality test
Unit : mSv

Group	H	M	L
1 cm dose equivalent	0.4	10	60
	2.0	20	150
	4.0	30	200
	6.0	40	350
	10.0	50	500
		60	600

Remarks : The same value of 1 cm dose equivalent shall be applied for each set.

- (2) **β -ray** Prepare 36 film badges consisting of badge film of the same lot. Take 3 pieces as one set, prepare 12 sets and take 6 sets in each as H group and M group. Irradiate β -ray to each set of each group in accordance with Table 6. However, take 1 set of each group as control films and do not irradiate β -ray.

Store the exposed badge films together with control film for 3 days and then develop them. Calculate the measured values from the high sensitivity film for H group and from medium sensitivity film for M group. Obtain the ratio of the response of 4.0 mSv for high sensitivity film, 30 mSv for medium sensitivity film to the response of each dose equivalent.

Table 6 Dose equivalent of proportionality test

Unit : mSv

Group	H	M
70 μ m dose equivalent	0.4	8
	2	15
	4	30
	6	40
	8	60

Remarks : The same value of 70 μ m dose equivalent shall be applied for each set.

6.2.5 Energy characteristic test

- (1) **X· γ -ray** Prepare 120 film badges consisting of badge films of the same lot. Take 5 pieces as one set, prepare 24 sets and take 8 sets in each as H group, M group and L group. Irradiate X· γ -ray to each set of each group in accordance with Table 7. However, take one set of each group as control films and do not irradiate X· γ -ray.

Store the exposed badge films together with control films for 3 days and then develop them. After the measured values were calculated from high sensitivity film for H group, from medium sensitivity film for M group and from low sensitivity film for L group, obtain the relative response for each energy.

Table 7 Dose equivalent for energy characteristic test of X· γ -ray

Energy of X· γ -ray keV	1 cm dose equivalent mSv		
	H group	M group	L group
20	0.26	3.4	24
30	0.21	2.1	15
45	0.20	1.7	12
70	0.28	2.4	17
100	0.43	3.6	28
662*	4.0	30	200
1250**	4.0	30	200

Notes* This is energy of γ -ray of ^{137}Cs .

** This is energy corresponding to equivalent conversion factor of γ -ray of ^{60}Co .

Remarks : The same value of dose equivalent and energy of X· γ -ray shall be applied for each set.

- (2) **β -ray** Prepare 30 film badges consisting of badge films of the same lot. Take 3 pieces as one set, prepare 10 sets and take 5 sets in each as H group and M group. Irradiate β -ray to each set of each group in accordance with Table 8. However, take

one set of each group as control films and do not irradiate β -ray.

Store the exposed badge films together with control films for 3 days and then develop them. After the measured values were calculated from high sensitivity film for H group, from medium sensitivity film for M group, and obtain the relative response for each energy.

Table 8 Dose equivalent for energy characteristic test of β -ray

Residual maximum energy of β -ray MeV	70 μ m dose equivalent mSv	
	H group	M group
0.6 (^{204}Tl)	12	110
1.3 ($^{90}\text{Sr}+^{90}\text{Y}$)	9	70
1.7 ($^{90}\text{Sr}+^{90}\text{Y}$)	7	45
2.2 ($^{90}\text{Sr}+^{90}\text{Y}$)	4	30

Remarks : The same value of dose equivalent and energy of β -ray shall be applied for each set.

6.2.6 Directional characteristic test of X· γ -ray Prepare 95 film badges consisting of badge film of the same lot. Take 5 pieces as 1 group and make 19 groups. Take 1 group out of them as control films and do not irradiate X· γ -ray. Take the normal direction to the front of film badge as 0° in incident angle and irradiate X· γ -ray given in Table 9 from total 9 directions of 0° , 30° top, bottom and left, right, and 60° top, bottom and left, right. For film badges, use one group in each direction and irradiate to each group successively.

Store the exposed badge films together with control films for 3 days and then develop them. After the measured values were calculated from the high sensitivity film, obtain the ratio of response in the case of irradiating from each direction to the response of 0° direction.

Table 9 Dose equivalent for directional characteristic test of X· γ -ray

X· γ -ray energy keV	1 cm dose equivalent mSv
45	0.2
662* or 1 250**	4.0

Notes * This is energy of γ -ray of ^{137}Cs .

** This is energy corresponding to equivalent conversion factor of γ -ray of ^{60}Co .

Remarks : The same value of dose equivalent shall be applied for each set.

6.2.7 Stability test for humidity Prepare 60 film badges consisting of badge film of the same lot. Take 5 pieces as one set, prepare 12 sets and take 4 sets in each as H group, M group and L group. Take 2 sets in each from each group and irradiate γ -ray of

^{137}Cs or ^{60}Co in accordance with Table 10. However, take 2 sets from each group as control films and do not irradiate γ -ray.

Store the exposed badge films together with control films at the environmental conditions as given in Table 11 and then develop them. Calculate the measured values from the high sensitivity film for H group, from medium sensitivity film for M group and from low sensitivity film for L group. Obtain the ratio of response of 90 % in relative humidity or over to the response of 50 % or under.

Table 10 Dose equivalent for stability test for humidity

Unit : mSv

Group	H	M	L
1 cm dose equivalent	4.0	30	200

Table 11 Storing environment of stability test for humidity

Set (common to each groups)		1st, 2nd	3rd, 4th
Storing environment	Ambient temperature °C	30 ± 5	
	Relative humidity %	90 min.	50 max.

Remarks : Concerning to the determination of 1st to 4th sets in this Table, take as 1st and 3rd set optionally out of 2 sets irradiated with γ -ray and as 2nd and 4th set optionally out of 2 sets taken as the control films.

6.2.8 Stability test for light Prepare 10 badge films consisting of badge film of the same lot. Take 5 pieces as one group, make 2 groups. Take one group out of them and irradiate the light of 1 000 Lx from its front and back directions for 1 h in each. Take the residual one group as the control films and do not irradiate light to it. After the badge films of 2 groups were developed, measure photographic density of the film and obtain the mean value and standard deviation for each group.

Furthermore, as for measurement of photographic density, the geometric condition and spectral condition shall be in accordance with JIS K 7652 and JIS K 7653, respectively.

7 Inspection The inspection shall be the type inspection and as for film badges of the same type, perform the tests according to 6 on the following items and take those complied with the specifications of 3 as acceptance.

- (1) Error of measured values and coefficient of variation (X· γ -ray, β -ray)
- (2) Characteristic variation by time of measured values
- (3) Proportionality of measured values (X· γ -ray, β -ray)
- (4) Energy characteristic (X· γ -ray, β -ray)
- (5) Directional characteristic of X· γ -ray