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**X-ray tube assemblies for medical use**

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## Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Health, Labour and Welfare and the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as a result of the proposal for revision of a Japanese Industrial Standard submitted by Japan Industries Association of Radiological Systems (JIRA)/Japanese Standards Association (JSA), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

Consequently, JIS Z 4704 : 1994 is replaced with this Standard.

In order to conform to the International Standard, this revision has been prepared based on IEC 60336 : 1993 *X-ray tube assemblies for medical diagnosis—Characteristics of focal spots*, IEC 60522 : 1999 *Determination of the permanent filtration of X-ray tube assemblies*, IEC 60601-2-28 : 1993 *Medical electrical equipment Part 2 : Particular requirements for the safety of X-ray source assemblies and X-ray tube assemblies for medical diagnosis* and IEC 60613 : 1989 *Electrical, thermal and loading characteristics of rotating anode X-ray tubes for medical diagnosis*.

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## X-ray tube assemblies for medical use

**Introduction** This Japanese Industrial Standard has been prepared based on the third edition of IEC 60336 *X-ray tube assemblies for medical diagnosis—Characteristics of focal spots* published in 1993, the second edition of IEC 60522 *Determination of the permanent filtration of X-ray tube assemblies* published in 1999, the first edition of IEC 60601-2-28 *Medical electrical equipment—Part 2 : Particular requirements for the safety of X-ray source assemblies and X-ray tube assemblies for medical diagnosis* published in 1993 and the second edition of IEC 60613 *Electrical, thermal and loading characteristics of rotating anode X-ray tubes for medical diagnosis* published in 1989 with some modifications of the technical contents.

Portions given sidelines or dotted underlines are the matters modified from the original International Standard. A list of modifications with the explanations is given in annex (informative).

**1 Scope** This Standard specifies X-ray tube assemblies for diagnosis, X-ray tube assemblies for medical CT and X-ray tube assemblies for therapy.

**Remarks :** The International Standards corresponding to this Standard are as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21.

IEC 60336 : 1993 *X-ray tube assemblies for medical diagnosis — Characteristics of focal spots*, IEC 60522 : 1999 *Determination of the permanent filtration of X-ray tube assemblies*, IEC 60601-2-28 : 1993 *Medical electrical equipment—Part 2 : Particular requirements for the safety of X-ray source assemblies and X-ray tube assemblies for medical diagnosis*, IEC 60613 : 1989 *Electrical, thermal and loading characteristics of rotating anode X-ray tubes for medical diagnosis* (MOD)

**2 Normative references** The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard.

If the indication of the year of coming into effect (or the year of publication) is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of coming into effect apply only to the most recent editions (including amendments).

JIS B 7516 : 1987 *Metal rules*

JIS C 1102-2 : 1997 *Direct acting indicating analogue electrical measuring instruments and their accessories Part 2: Special requirements for ammeters and voltmeters*

JIS H 3100 : 2000 *Copper and copper alloy sheets, plates and stripes*

JIS H 4000 : 1999 *Aluminium and aluminium alloy sheets and plates, strips and coiled sheets*

JIS T 0601-1 : 1999 *Medical electrical equipment—Part 1: General requirements for safety*

Remarks : IEC 60601-1 : 1988 *Medical electrical equipment—Part 1 : General requirements for safety* and Amendment 1 : 1991 and Amendment 2 : 1995 are identical with the said standard.

JIS Z 4004 : 1989 *Graphical symbols for medical radiological equipment*

JIS Z 4005 : 1991 *Medical radiology—Terminology*

Remarks : IEC 60788 : 1984 *Medical radiology—Terminology* is identical with the said standard.

JIS Z 4511 : 1999 *Methods of calibration for exposure meters and dose-equivalent meters*

JIS Z 4701 : 1997 *General rules for medical X-ray equipment*

JIS Z 4702 : 1999 *General requirements for high-voltage generators of medical X-ray apparatus*

Remarks : IEC 60601-2-7: 1998 *Medical electrical equipment—Part 2-7 : Particular requirements for the safety of high-voltage generators of diagnostic X-ray generators* is equivalent to the said standard.

JIS Z 4711 : 1997 *Mono tank X-ray generators for diagnostic use*

JIS Z 4731 : 1982 *High voltage cable plug and socket for medical X-ray equipment*

JIS Z 4916 : 1997 *Test charts for resolution characteristics of X-ray equipment*

**3 Definitions** For the purposes of this Standard, the definitions given in JIS Z 4005 and JIS Z 4701, and the following definitions apply.

The [bracketed] terms were used in the previous Japanese Industrial Standards.

- a) **medical X-ray tube assembly** the assemblies where a medical X-ray tube is sealed in the protective X-ray tube housing (hereafter referred to as “X-ray tube assemblies”)
- b) **protective X-ray tube housing** the electric shock proof housing which is provided with the specific X-ray shield and connectors for X-ray high voltage cable and which houses the medical X-ray tube (hereafter referred to as a “tube housing”)
- c) **medical X-ray tube** vacuum tube for medical use where the electron beam from the cathode is accelerated by the electrical field and strikes the target, and its impact generates X-rays (hereafter referred to as an “X-ray tube”). The target is usually contained in the anode.
- d) **grid-controlled X-ray tube** X-ray tube with the grid electrode which controls tube current
- e) **stereo X-ray tube** X-ray tube which has plural focal spots distanced from each other, and is used in such a radiographic manner that the same subject is

radiographed with these two focal spots switched and the stereoradiograms can be produced using the images thus obtained

- f) **effective focal spot** vertical projection of the actual focal spot to a reference plane (hereafter referred to as a “focal spot”)

The designation of an effective focal spot is usually the absolute number expressed in millimetres of its size in the direction perpendicular to an X-ray tube axis (width) and of its size in the direction parallel to an X-ray tube axis (length).

- g) **blooming value** value of the ratio of two resolution limits acquired according to specific loading conditions, which shows the characteristic of the effective focal spot of an X-ray tube
- h) **MTF (modulation transfer function)** the Fourier Transform of a line spread function. In a symmetrical line spread function, a modulation transfer function (MTF) is the Fourier Transform which is normalized using the following formula.

$$M(\nu) = \frac{\int_{-\infty}^{\infty} L(x) \cos(2\pi\nu x) dx}{\int_{-\infty}^{\infty} L(x) dx}$$

Where,  $\nu$  : spatial frequency  
 $L$  : line spread function  
 $x$  : lateral coordinates  
 $M$  : quantifier

- i) **target** portion of an X-ray tube where an impact is given by the electron beam in order to generate X-rays
- j) **target angle** angle which a real focal spot plane and a reference axis make
- k) **X-ray tube voltage** potential difference applied to an X-ray tube between the anode and the cathode (hereafter referred to as “tube voltage”). Usually, tube voltage shall be given as the peak value, in kilovolt (kV).
- l) **nominal X-ray tube voltage [maximum operating tube voltage]** highest permitted tube voltage for the specified <sup>(1)</sup> operating condition and voltage waveform. Unless otherwise specified <sup>(1)</sup>, this value shall not be exceeded for any operating conditions.

Note <sup>(1)</sup> The word “specified” means “specified by a manufacturer in the accompanying documents”.

- m) **X-ray tube voltage for charging** potential difference applied to an X-ray tube between the anode and the cathode of the grid-controlled X-ray tube assembly at the time of charge of the high-voltage capacitor.

- n) **nominal maximum charge tube voltage** [**maximum operating charge tube voltage**] highest permitted value of charge tube voltage
- o) **reverse voltage** tube voltage when negative potential against the cathode is applied to the anode. Reverse voltage is used to distinguish from tube voltage when positive potential is applied to the anode, and is given as the peak value in kilovolts (kV).
- p) **nominal maximum reverse voltage** [**maximum operating reverse voltage**] highest permitted value of reverse voltage
- q) **X-ray tube current** the current of the electron beam reaching the target of an X-ray tube (hereafter referred to as “tube current”). Tube current shall be given as the average value in milliamperes (mA). However, in the radiography performed using the capacitor type X-ray generator, the peak value shall be given in milliamperere peak (mAp).

Remarks : The tube current is generally measured at the anode side. However, when the X-ray tube of the metal envelope is used, the current flowing through the cathode side circuit shall be tube current.

- r) **X-ray tube current characteristics** relation of the tube current and the filament current under the specified <sup>(1)</sup> X-ray tube loading factor
- s) **filament characteristics** relation of the voltage applied to the filament and the filament current

Remarks : The highest permitted filament current under the specified <sup>(1)</sup> operating condition is called maximum filament current. Usually, the maximum value for the long-time use filament current and the short-time use filament current are different from each other.

- t) **loading** act of supplying electrical energy to the anode of an X-ray tube
- u) **X-ray tube load** electrical energy supplied to an X-ray tube expressed by a combination of values of X-ray tube loading factor
- v) **X-ray tube loading factor** factor influencing the X-ray tube load value, for example, X-ray tube current, loading time, equivalent anode input power, X-ray tube voltage, and percentage ripple
- w) **loading time** time, determined by a specific method <sup>(2)</sup>, during which the anode input power is applied to the X-ray tube

Note <sup>(2)</sup> See JIS Z 4702 [3 Definitions x) Radiographic time].

- x) **anode input power** [**X-ray tube input power**] electric power applied to the anode of an X-ray tube to produce X-rays. This electric power is given by the following formula.

$$P = U \times I \times f \times 10^{-3}$$

Where,  $P$  : anode input power (kW)

$U$  : tube voltage (kV)

$I$ : tube current (mA)

$f$ : the constant which is determined by the percentage ripple of tube voltage. Where,

$f = 1.0$  : for a percentage ripple 10 % or less

$f = 0.95$  : for a percentage ripple over 10% to and including 25 %

$f = 0.74$  : for a percentage ripple 25 % or over

Remarks : A tube-voltage percentage ripple is given by the following formula.

$$\Delta U = \frac{U_{\max} - U_{\min}}{U_{\max}} \times 100$$

Where,  $\Delta U$  : percentage ripple (%)

$U_{\max}$  : the peak value of a tube-voltage waveform

$U_{\min}$  : the minimum value of a tube-voltage waveform (however, the spike waveform of a voltage stabilizer is excluded.)

- y) **nominal anode input [maximum input]** the highest constant anode input power that can be applied in the specified loading time and under the specified <sup>(1)</sup> operating condition. The operating conditions mean the designation of a focal spot, tube voltage, tube-voltage waveform, and anode speed of a rotating anode X-ray tube, etc.
- z) **heat unit** special unit showing the input of an X-ray tube. The unit symbol for the heat unit shall be HU and a heat unit value is calculated by the following formula according to a high-voltage transformer assembly.

In addition, meaning of symbols used here shall be as follows:

$U$ : tube voltage (kV)

$I$ : tube current (mA)

$t$ : loading time (s)

$C$ : capacitor capacity ( $\mu$  F)

- 1) In the case of the single-phase full-wave rectifier, single-phase half-wave rectifier or self rectified circuit

$$\text{HU value} = U \times I \times t$$

$$\text{HU value per 1 s} = U \times I$$

- 2) In the case of the three-phase full-wave rectifier or the circuit having equivalent percentage ripple

$$\text{HU value} = U \times I \times t \times 1.35$$

$$\text{HU value per 1 s} = U \times I \times 1.35$$

- 3) In the case of the constant voltage circuit

$$\text{HU value} = U \times I \times t \times 1.41$$

$$\text{HU value per 1 s} = U \times I \times 1.41$$

- 4) In the case of a capacitor type

$$\text{HU value} = 0.71 \times C \times (U_1^2 - U_2^2),$$

where  $U_1$  expresses the tube voltage at the commencement of discharge, and  $U_2$  expresses the tube voltage at the time of electric discharge termination.

Remarks : Conversion between HU value and other units is performed noting that 1 HU is equivalent to 0.71 J.

- aa) **equivalent anode input power** values of the anode input power which, if applied continuously under the specified <sup>(1)</sup> ambient conditions, would maintain a specific level of anode heat content. With respect to radiographic ratings, the electric power which maintains the highest level of initial anode heat content for which the radiographic rating is valid.

- ab) **X-ray tube maximum continuous input [long-time maximum input]** maximum of the anode input power which can be continuously applied under the specified <sup>(1)</sup> conditions in the range which does not exceed a maximum anode heat content

- ac) **maximum single loading ratio [short-time maximum input]** maximum of the X-ray tube load permitted for one loading, which is determined under the specified <sup>(1)</sup> conditions by a relationship between anode input power and loading time. Unless otherwise specified <sup>(1)</sup>, it refers to the value in the cold condition.

Remarks : In this Standard, the cold condition shall be the condition where the anode heat content is zero in an anode cooling curve chart.

- ad) **X-ray tube repeatable maximum input** highest permitted X-ray tube load given by the relationship between anode input power and loading time for a total of a specified series of individual X-ray tube loads according to the specified <sup>(1)</sup> X-ray tube loading factors

- ae) **X-ray tube assembly input power** average power applied to the X-ray tube assembly before, during and after loading for every purpose. It includes power supply applied to all apparatuses included in a stator, filament and an X-ray tube assembly of rotating anode X-ray tube.

- af) **maximum continuous heat dissipation** maximum of X-ray tube assembly input power which can be continually applied to the X-ray tube assembly under the specified <sup>(1)</sup> condition, within the range of maximum X-ray tube assembly heat content

- ag) **anode heat content** instantaneous value of the heat contained in the anode of an X-ray tube accumulated during, or retained after, loading

- ah) **maximum anode heat capacity [anode accumulating heat content]** maximum of

the anode heat content permitted

- ai) anode heat up curve curve showing the anode heat content as a function of loading time for specified <sup>(1)</sup> anode input power
- aj) anode cooling curve curve showing the anode heat content as a function of time with zero anode input power, after loading until the anode heat content is equal to the maximum anode heat content

Remarks : In this time sequence, the rate that an **anode heat content** decreases is called anode cooling rate, and that the maximum value is called anode maximum cooling rate.

- ak) X-ray tube assembly heat content instantaneous value of the heat accumulated or retained in the X-ray tube assembly
- al) maximum X-ray tube assembly heat content [X-ray tube assembly accumulating heat content] maximum of the X-ray tube assemblies heat content permitted under the specified ambient condition
- am) X-ray tube assembly heating curve curve showing the X-ray tube assembly heat content as a function of input time for specified <sup>(1)</sup> X-ray tube assembly input power
- an) X-ray tube assembly cooling curve curve showing the X-ray tube assembly heat content as a function of time with zero X-ray tube assembly input power, beginning after when the X-ray tube assembly heat content is equal to the maximum X-ray tube assembly heat content

Remarks 1 In the case of the X-ray tube assemblies provided with the cooling mechanism, a curve may show the change of the retained heat content without cooling.

2 Like the anode cooling curve, the X-ray tube assembly cooling rate and the X-ray tube assembly maximum cooling rate shall be determined.

- ao) rated anode speed anode speed required when applying the anode input power to an X-ray tube
- ap) starting time time required for the anode to reach rated anode speed from a state of rest under the specified <sup>(1)</sup> conditions
- aq) braking time time required for the anode to be braked from rated anode speed to the specified <sup>(1)</sup> revolving speed under the specified <sup>(1)</sup> conditions
- ar) stator a stator of a motor used to rotate the anode of the rotating anode X-ray tube
- as) stator starting voltage the voltage supplied to a stator when the anode starts to rotate, by supplying power to a stator when the anode is at rest
- at) stator stationary voltage the stator voltage required to maintain the rated anode speed
- au) stator power source frequency the frequency of power to be supplied to a stator

- av) **X-ray tube assembly utilization beam** the X-ray beam emitted directly from the focal spot of the X-ray tube and limited by the radiation window of the tube housing, etc. (hereafter referred to as a “utilization beam”)
- aw) **X-ray radiation angle** vertical angle of the maximum utilization beam
- ax) **reference axis** with respect to X-ray tube assemblies, the specified <sup>(1)</sup> axis which passes through a centre of focal spot and serves as a reference
- ay) **reference plane** with respect to the effective focal spot of X-ray tube assembly, the plane which includes an intersecting point of a reference axis with an actual focal spot, and which is perpendicular to a reference axis
- az) **maximum symmetry field** the field where the radiation dose is kept within the specific value at the reference axis, at the side parallel to the reference axis on the image receptor plane symmetric to the specified <sup>(1)</sup> reference axis, when the Source Image Distance (hereafter referred to as “SID”) has been specified <sup>(1)</sup> [see 6.1 n)]
- ba) **permanent filtration** quality equivalent filtration by the substance which cannot be removed. Permanent filtration is the basis of the specified <sup>(1)</sup> tube voltage and tube-voltage waveform, and is expressed with the thickness of the reference substance which gives the same quality of radiation by conversion into the first half-value layer
- bb) **leakage dose** <sup>(3)</sup> the X-ray dose that does not penetrate the radiation aperture but penetrates the X-ray tube housing. In some types of X-ray tube assemblies (for example, those using a grid-controlled X-ray tube), the leakage dose includes the X-ray which penetrates the radiation aperture before and after loading
- Note <sup>(3)</sup> The X-ray dose is the air kerma which is measured in air.
- bc) **measuring conditions for leakage dose** <sup>(3)</sup> the X-ray tube loading factors which are applied to measurement of the leakage dose <sup>(3)</sup> of X-ray tube assemblies
- The conditions shall be indicated by the tube voltage, tube voltage waveform, tube current and the circuit used [according to clause 2 (55) in JIS Z 4701].
- bd) **socket** that portion provided to the tube housing where the X-ray high voltage cable is to be inserted

## 4 Classification and model name

### 4.1 Classification

4.1.1 **X-ray tube assembly for diagnosis** The classification and model name of an X-ray tube assembly for diagnosis shall be as follows:

- a) **Fixed anode X-ray tube assembly** It consists of a combination of the following items.
- 1) **According to control** 2-pole type, grid-controlled type
  - 2) **Number of focal spots** Single focal spot type, multiple focal spot type

- 3) **Designation of focal spot** 2.5, 2.0, 1.5, 1.0, and 0.8 and 0.6 shall be a standard.
- b) **Rotating anode X-ray tube assembly** It consists of a combination of the following items.
- 1) **According to control** 2-pole type, grid-controlled type
  - 2) **Number of focal spots** Single focal spot type, multiple focal spot type
  - 3) **Designation of focal spot** 2.0, 1.5, 1.2, 1.0, 0.8, 0.6, 0.3, 0.2 and 0.1 shall be a standard.
  - 4) **Anode speed** Ordinary rotation type, high-speed rotation type

**Remarks 1** X-ray tube assemblies for diagnosis contain the X-ray tube assemblies of a particular application. Therefore, especially when required, they may be referred to as a class where the intended use is limited.

**Example :** X-ray tube assemblies for mammography, X-ray tube assemblies for stereoradiography, etc.

**Remarks 2** With respect to **anode speed**, the ordinary rotation shown here means rotation speed which is driven by the stator power supply of frequency 50 Hz or 60 Hz of a power supply (commercial), and it shall be  $2\,700\text{ min}^{-1}\{\text{rpm}\}$  or more for steady state 50 Hz, and  $3\,200\text{ min}^{-1}\{\text{rpm}\}$  or more for 60 Hz. The high-speed rotation means the rotation where the driving frequency of a power supply exceeds 60 Hz of commercial frequency.

**4.1.2 X-ray tube assemblies for medical X-ray CT** The class and model name of an X-ray tube assembly for medical X-ray CT shall be as follows:

- a) **X-ray tube assemblies for fixed anode medical use X-ray CT** It consists of a combination of the following items.
- 1) **According to control** 2-pole type, grid-controlled type
  - 2) **Number of focal spots** Single focal spot type, multiple focal spot type
  - 3) **Designation of focal spots** 2.0, 1.5, 1.2, 1.0, 0.8 and 0.6 shall be a standard.
- b) **X-ray tube assemblies for rotating anode medical use X-ray CT** It consists of a combination of the following items:
- 1) **According to control** 2-pole type, grid-controlled type
  - 2) **Number of focal spots** Single focal spot type, multiple focal spot type
  - 3) **Designation of focal spots** 2.0, 1.5, 1.2, 1.0, 0.8 and 0.6 shall be a standard.
  - 4) **Anode speed** Ordinary revolution type, high-speed revolution type

**Remarks :** Ordinary revolution type and high-speed revolution type shall be specified in remarks 2 of 4.1.1 b) 4).

**4.1.3 X-ray tube assemblies for therapy** The classification and model name of an X-ray tube assemblies for therapy shall be as follows:

- a) **X-ray tube assemblies for deep radiotherapy** It is classified by the highest operating tube voltage.

Example : For 200 kV, for 250 kV

- b) **X-ray tube assemblies for superficial radiotherapy** It is classified by the highest operating tube voltage and a radiation aperture filter medium.

- 1) Maximum operating tube voltage

Example : For 10 kV, for 25 kV, for 50 kV

- 2) Radiation aperture filter medium

Example : Beryllium, mica

**4.2 Model name** Model name shall be constituted by class, and expressed with the combination of the following characters and numbers.

|             |             |             |                   |             |
|-------------|-------------|-------------|-------------------|-------------|
| 1st item    | 2nd item    | 3rd item    | 4th item—5th item | 6th item    |
| “Character” | “Character” | “Character” | “Number-number”   | “Character” |

The character and number of each item shall be as follows:

- a) The 1st item shall express the intended use of an X-ray tube assemblies as shown in table 1.
- b) The 2nd item shall express the structure of an X-ray tube assemblies as shown in table 2. However, a **grid-controlled type** shall express what is used in combination with a capacitor type X-rays generator. A stereo type shall contain **grid-controlled stereo X-ray tube assemblies**.

With respect to rotating anode type **multiple focal spot X-ray tube assemblies**, F shall be omitted.

**Table 1 Classification of model name by the intended use**

| Classification by the intended use                 | Character of the 1st item |
|----------------------------------------------------|---------------------------|
| Fixed anode X-ray tube assemblies for diagnosis    | D                         |
| Rotating anode X-ray tube assemblies for diagnosis | R                         |
| Rotating anode X-ray tube assemblies for X-ray CT  | C                         |
| Fixed anode X-ray tube assemblies for X-ray CT     | K                         |
| X-ray tube assemblies for therapy                  | T                         |

**Table 2 Classification of model name by structure**

| Classification by structure | Character of the 2nd item |
|-----------------------------|---------------------------|
| Multiple focal spot type    | F                         |
| Grid-controlled type        | G                         |
| Stereo type                 | S                         |

- c) The 3rd item is X, indicating that the tube housing contains the X-ray tube.
- d) The 4th item is the value of **nominal X-ray tube voltage** expressed in kilovolts (kV).
- e) The 5th item is the value of **nominal anode input power** [see clause 3 y) and 5.1 n)] in each focal spot expressed in kilowatts (kW) for diagnosis, or the value of **long-time maximum input** [see clause 3 ab) and 5.1 o)] expressed in watts (W) for treatment.
- f) The 6th item expresses aperture material of an X-ray tube with the following characters. However, aperture material of ordinary glass is omitted.
  - 1) Equipped with a beryllium aperture    B
  - 2) Equipped with a mica aperture    M

Remarks : An example of model name is as follows. For **grid-controlled rotating anode X-ray tube assemblies** with a beryllium aperture, the **nominal X-ray tube voltage** of 80 kV, the **nominal anode input power** of 20 kW and 50 kW at a small focal spot and a large focal spot, respectively: RGX80—20/50B.

## 5 Rating

**5.1 X-ray tube assemblies for diagnosis** The rating shall be shown with the material, numerical value, etc. of the following items. Unrelated items depending on the class of X-ray tube assemblies may be omitted.

Remarks : The units W and J may be accompanied by values of HU/s and HU, respectively.

- a) **Designation of focal spots and focal reference axis** Designation of focal spots shall be shown with the size of width×length.

Remarks : When the designation of width and length is the same, either of them may be shown. A **reference axis** is shown in the outline drawing of accompanying documents.

- b) **Quality of target material**
- c) **Target angle (°)**
- d) **Nominal X-ray tube voltage (kV)**
- e) **Nominal maximum charge voltage (kV)**
- f) **Nominal maximum reverse voltage (kV)**
- g) **Nominal maximum anode—earth voltage (kV)**
- h) **Nominal maximum anode—earth reverse voltage (kV)**
- i) **Nominal maximum cathode—earth voltage (kV)**
- j) **Nominal maximum cathode—earth reverse voltage (kV)**
- k) **Maximum filament—grid voltage (V)**

l) **Tube current interruption grid voltage (V)**

Remarks : Potential difference against filament

m) **Filament heating**1) **Maximum filament current (A)**2) **Maximum filament voltage (V)**

Remarks : The maximum filament voltage shown here is the maximum of the filament voltage at the maximum filament current.

n) **Nominal anode input power (kW)**

Remarks : It is the allowable maximum value of anode input power of 0.1 s for a rotating anode X-ray tube, and of 1 s for fixed anode X-ray tube.

o) **X-ray tube maximum continuous input (W)**p) **Maximum single load rating**q) **X-ray tube assemblies maximum continuous input (W)**r) **Maximum anode heat capacity (J)**s) **Maximum X-ray tube assemblies heat capacity (J)**t) **Anode heat up curve**

Remarks : With anode input power (W) being a parameter, the curve shows the anode heat content (J) as a function of loading time (s or min).

u) **Anode cooling curve**

Remarks : With anode input power (W) being at zero, the curve shows the anode heat content (J) as a function of time (s or min).

v) **Anode maximum cooling rate (W)**w) **X-ray tube assemblies heat up curve (W)**

Remarks : With X-ray tube assembly input power (W) being a parameter, the curve shows the X-ray tube assembly heat content (J) as a function of input time (min or h).

x) **X-ray tube assemblies cooling curve**

Remarks : With X-ray tube assembly input power (W) being at zero, the curve shows the X-ray tube assembly heat content (J) as a function of time (min or h).

y) **X-ray tube assembly maximum cooling rate (W)**z) **Rated anode speed ( $\text{min}^{-1}$ ) {rpm}**aa) **Starting time (s)**ab) **Braking time (s)**ac) **X-ray radiation angle ( $^{\circ}$ )**

- ad) **Maximum symmetrical radiation field (mm) and SID (mm) which produces that maximum symmetrical radiation field**

Remarks : If the dose ratio against the dose <sup>(3)</sup> of **reference axis** in the **maximum symmetrical radiation field** is specified <sup>(1)</sup> to a certain specific value which is different from the specification, that value (%) shall also be written.

- ae) **Permanent filtration (mmCu, mmAl, mmBe)**

- 1) With respect to **X-ray tube assemblies** used mainly for diagnosis, it is expressed by the thickness of aluminum for **nominal X-ray tube voltage** not exceeding 150 kV, and by thickness of copper for **X-ray tube assemblies** exceeding 150 kV.
- 2) With respect to the **X-ray tube assemblies** where the window of **X-ray tube** consists only of beryllium, it is expressed by the thickness of beryllium or aluminum.

Remarks : If it consists of other substance of very low X-ray absorption, for example mica, then it is expressed with thickness of that substance.

- af) **Leakage dose <sup>(3)</sup> (mGy)**

- ag) **Leakage dose <sup>(3)</sup> measurement condition**

- ah) **Cooling system**

- ai) **Mass (kg)**

**5.2 X-ray tube assemblies for medical X-ray CT** The rating of X-ray tube assemblies for diagnosis shall apply.

**5.3 X-ray tube assemblies for therapy** The rating shall be shown with the material, numerical value, etc. of the following items. Unrelated items depending on the class of the X-ray tube assembly may be omitted.

- a) **Quality of target material**
- b) **Target angle (° )**
- c) **Nominal X-ray tube voltage (kV)**
- d) **Nominal maximum reverse voltage (kV)**
- e) **Nominal maximum anode—earth voltage (kV)**
- f) **Nominal maximum anode—earth reverse voltage (kV)**
- g) **Nominal maximum cathode—earth voltage (kV)**
- h) **Nominal maximum cathode—earth reverse voltage (kV)**
- i) **Maximum tube current at nominal X-ray tube voltage (mA)**
- j) **Filament heating**
  - 1) **Maximum filament current (A)**

## 2) Maximum filament voltage (V)

Remarks : The maximum filament voltage shown here is the maximum of the filament voltage at the maximum filament current.

## k) X-ray radiation angle (°)

## l) Permanent filtration (mmCu, mmBe, mmAl)

- 1) With respect to X-ray tube used mainly for therapy, it is expressed by the thickness of copper for nominal X-ray tube voltage of 150 kV or more to and including 400 kV.
- 2) With respect to the X-ray tube assemblies where the window of X-ray tube consists only of beryllium, it is expressed with the thickness of beryllium or aluminum.

Remarks : If it consists of other substance of very low X-ray absorption, for example mica, then it is expressed with thickness of that substance.

m) Leakage dose <sup>(3)</sup> (mGy)n) Leakage dose <sup>(3)</sup> measurement condition

## o) Cooling system

## p) Mass (kg)

## 6 Performance

6.1 Matters related to the characteristics The characteristics shall comply with each of the following items, when tested by the method specified in clause 8.

- a) Focal spot dimensions by the slit camera method For the slit camera method, the permissible values of focal spot dimensions, width and length, shall be as specified in table 3.

Table 3 Permissible range of focal spot dimensions,  
width and length (slit camera method)

Unit : mm

| Nominal focal spot values<br><i>f</i> | Width        | Length       |
|---------------------------------------|--------------|--------------|
| 0.1                                   | 0.10 to 0.15 | 0.10 to 0.15 |
| 0.15                                  | 0.15 to 0.23 | 0.15 to 0.23 |
| 0.2                                   | 0.20 to 0.30 | 0.20 to 0.30 |
| 0.3                                   | 0.30 to 0.45 | 0.45 to 0.65 |
| 0.4                                   | 0.40 to 0.60 | 0.60 to 0.85 |
| 0.5                                   | 0.50 to 0.75 | 0.70 to 1.10 |
| 0.6                                   | 0.60 to 0.90 | 0.90 to 1.30 |
| 0.7                                   | 0.70 to 1.10 | 1.00 to 1.50 |
| 0.8                                   | 0.80 to 1.20 | 1.10 to 1.60 |