

# INTERNATIONAL STANDARD

**Medical electrical equipment –  
Part 2-44: Particular requirements for the safety of X-ray equipment for  
computed tomography**

IEC 60601-2-44:2001

<https://standards.iteh.ai/standards/iec/3c538c7c8-3896-46d9-b1cf-ee8bd0312539/iec-60601-2-44-2001>

Withhold





## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2002 IEC, Geneva, Switzerland

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 either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Email: [inmail@iec.ch](mailto:inmail@iec.ch)  
Web: [www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: [www.iec.ch/webstore/custserv](http://www.iec.ch/webstore/custserv)

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: [csc@iec.ch](mailto:csc@iec.ch)

Tel.: +41 22 919 02 11

Fax: +41 22 919 03 00

IEC 60601-2-44:2001

<https://standards.iec.org/3d58c7c8-3896-46d9-b1cf-ee8bd0312539/iec-60601-2-44-2001>

# INTERNATIONAL STANDARD

---

**Medical electrical equipment –  
Part 2-44: Particular requirements for the safety of X-ray equipment for  
computed tomography**

<https://standards.iteh.ai/standards/iec/3d58c7c8-3896-46d9-b1cf-ee8bd0312539/iec-60601-2-44-2001>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

PRICE CODE **CM**

## CONTENTS

FOREWORD ..... 4

### SECTION 1: GENERAL

1 Scope and object ..... 6

1.1 Scope ..... 6

1.2 Object ..... 6

1.3 Particular Standards ..... 7

2 Terminology and definitions ..... 8

3 General requirements ..... 11

5 Classification ..... 11

6 Identification, marking and documents ..... 11

6.1 Marking on the outside of EQUIPMENT or EQUIPMENT parts ..... 11

6.7 Indicator lights and push-buttons ..... 12

6.8 ACCOMPANYING DOCUMENTS ..... 12

### SECTION 2: ENVIRONMENTAL CONDITIONS

10 Environmental conditions ..... 14

### SECTION 3: PROTECTION AGAINST ELECTRIC SHOCK HAZARDS

15 Limitation of voltage and/or energy ..... 15

16 ENCLOSURES and PROTECTIVE COVERS ..... 15

19 Continuous LEAKAGE CURRENTS and PATIENT AUXILIARY CURRENTS ..... 15

19.3 Allowable values ..... 15

20 Dielectric strength ..... 16

20.3 Values of test voltages ..... 16

20.4 Tests ..... 16

### SECTION 4: PROTECTION AGAINST MECHANICAL HAZARDS

22 Moving parts ..... 18

27 Pneumatic and hydraulic power ..... 19

### SECTION 5: PROTECTION AGAINST HAZARDS FROM UNWANTED OR EXCESSIVE RADIATION

29 X-RADIATION ..... 20

36 Electromagnetic compatibility ..... 28

SECTION 6: PROTECTION AGAINST HAZARDS OF IGNITION OF  
FLAMMABLE ANAESTHETIC MIXTURES

SECTION 7: PROTECTION AGAINST EXCESSIVE TEMPERATURES AND  
OTHER SAFETY HAZARDS

|    |                              |    |
|----|------------------------------|----|
| 42 | Excessive temperatures ..... | 29 |
|----|------------------------------|----|

SECTION 8: ACCURACY OF OPERATING DATA AND PROTECTION  
AGAINST HAZARDOUS OUTPUT

|        |   |    |
|--------|---|----|
| 50     | Accuracy of operating data .....            | 29 |
| 50.101 | Accuracy of radiation output .....          | 29 |
| 50.102 | Accuracy of recorded examination data ..... | 29 |
| 51     | Protection against hazardous output.....    | 30 |

SECTION 9: ABNORMAL OPERATION AND FAULT CONDITIONS,  
ENVIRONMENTAL TESTS

SECTION 10: CONSTRUCTIONAL REQUIREMENTS

|       |   |    |
|-------|---|----|
| 56    | Components and general assembly.....        | 31 |
| 56.7  | Batteries .....                             | 31 |
| 57    | MAINS PARTS, components and layout .....    | 31 |
| 57.10 | CREEPAGE DISTANCES and AIR CLEARANCES ..... | 31 |

Tables

|     |  |    |
|-----|--|----|
| 101 | HALF-VALUE LAYERS in CT SCANNERS ..... | 26 |
|-----|--|----|

Figures

|     |                         |   |
|-----|-------------------------|---|
| 101 | Coordinate system ..... | 9 |
|-----|-------------------------|---|

|                      |  |    |
|----------------------|--|----|
| Annex AA (normative) | Terminology – Index of defined terms ..... | 32 |
|----------------------|--|----|

|                        |   |    |
|------------------------|---|----|
| Annex BB (informative) | Choosing LOADING FACTORS for tests..... | 35 |
|------------------------|---|----|

|                   |    |
|-------------------|----|
| Bibliography..... | 36 |
|-------------------|----|

# INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

## MEDICAL ELECTRICAL EQUIPMENT –

### Part 2-44: Particular requirements for the safety of X-ray equipment for computed tomography

#### FOREWORD

- 1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
- 3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
- 4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
- 5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
- 6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60601-2-44 has been prepared by subcommittee 62B: Diagnostic imaging equipment, of IEC technical committee 62: Electrical equipment in medical practice.

This consolidated version of IEC 60601-2-44 consists of the second edition (2001) [documents 62B/426/FDIS and 62B/437/RVD] and its amendment 1 (2002) [documents 62B/472/FDIS and 62B/478/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

Annex AA forms an integral part of this standard.

Annex BB is for information only.

In this standard, the following print types are used:

- requirements, compliance with which can be tested and definitions: roman type;
- explanations, advice, notes, general statements and exceptions: smaller type;
- *test specifications and headings of subclauses: italic type;*
- TERMS DEFINED IN CLAUSE 2 OF THE GENERAL STANDARD OR IN IEC 60788: SMALL CAPITALS.

The committee has decided that the contents of the base publication and its amendment 1 will remain unchanged until 2004. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

WITHDRAWN

iTech Standards  
(<https://standards.iteh.ai>)  
Document Preview

[IEC 60601-2-44:2001](https://standards.iteh.ai/standards/iec/3a28e7c8-3896-46d9-b1cf-ee8bd0312539/iec-60601-2-44-2001)

<https://standards.iteh.ai/standards/iec/3a28e7c8-3896-46d9-b1cf-ee8bd0312539/iec-60601-2-44-2001>

## MEDICAL ELECTRICAL EQUIPMENT –

### Part 2-44: Particular requirements for the safety of X-ray equipment for computed tomography

#### SECTION 1: GENERAL

The clauses and subclauses of this section of the General Standard apply except as follows:

#### 1 Scope and object

This clause of the General Standard applies except as follows:

##### 1.1 Scope

*Addition:*

This Particular Standard applies to X-RAY EQUIPMENT for COMPUTED TOMOGRAPHY (CT SCANNERS).

It includes safety requirements for the X-RAY GENERATOR, and those where HIGH VOLTAGE GENERATORS are integrated with an X-RAY TUBE ASSEMBLY.

##### 1.2 Object

*Replacement:*

The object of this standard is to establish particular requirements to ensure safety, and to specify methods for demonstrating compliance with those requirements, for CT SCANNERS.

NOTE 1 Requirements for reproducibility, linearity, constancy and accuracy are given because of their relationship to the quality and quantity of the IONIZING RADIATION produced and are confined to those considered necessary for safety.

NOTE 2 Both the levels for compliance and the tests prescribed to determine compliance reflect the fact that the safety of HIGH-VOLTAGE GENERATORS is not sensitive to small differences in levels of performance. The combinations of LOADING FACTORS specified for the tests are therefore limited in number but chosen from experience as being appropriate in most cases. It is considered important to standardize the choice of combinations of LOADING FACTORS so that comparison can be made between tests performed in different places on different occasions. However, combinations other than those specified could be of equal technical validity.

NOTE 3 The safety philosophy on which this standard is based is described in the introduction to the General Standard and in IEC 60513.

NOTE 4 Concerning RADIOLOGICAL PROTECTION it has been assumed in the preparation of this standard that MANUFACTURERS and USERS do accept the general principles of the ICRP as stated in ICRP 60, 1990, paragraph 112,<sup>1)</sup> namely:

"(a) No practice involving exposures to radiation should be adopted unless it produces sufficient benefit to the exposed individuals or to society to offset the radiation detriment it causes. (The justification of a practice.)

(b) In relation to any particular source within a practice, the magnitude of individual doses, the number of people exposed, and the likelihood of incurring exposures where these are not certain to be received should all be kept as low as reasonably achievable, economic and social factors being taken into account. This procedure should be constrained by restrictions on the doses to individuals (dose constraints), or the risks to individuals in the case of potential exposures (risk constraints), so as to limit the inequity likely to result from the inherent economic and social judgements. (The optimisation of protection.)

<sup>1)</sup> ICRP Publication 60: *Recommendations of the International Commission on Radiological Protection (Annals of the ICRP Vol. 21 No 1-3, 1990)*. Published by Pergamon Press.



(c) The exposure of individuals resulting from the combination of all the relevant practices should be subject to dose limits, or to some control of risk in the case of potential exposures. These are aimed at ensuring that no individual is exposed to radiation risks that are judged to be unacceptable from these practices in any normal circumstances. Not all sources are susceptible of control by action at the source and it is necessary to specify the sources to be included as relevant before selecting a dose limit. (Individual dose and risk limits.)"

NOTE 5 Most of the requirements on X-RAY EQUIPMENT and its sub-assemblies for protection against IONIZING RADIATION are given in the Collateral Standard IEC 60601-1-3.

This standard does, however, deal with some aspects of RADIOLOGICAL PROTECTION, mainly those that depend upon the supply, control and indication of electrical energy from the HIGH-VOLTAGE GENERATOR.

NOTE 6 It is recognized that many of the judgements necessary to follow the ICRP general principles have to be made by the USER and not by the MANUFACTURER of the EQUIPMENT.

### 1.3 Particular Standards

#### *Addition:*

This Particular Standard, hereinafter referred to as "this standard", amends and supplements a set of IEC publications, hereinafter referred to as "General Standard", consisting of IEC 60601-1:1988, *Medical electrical equipment – Part 1: General requirements for safety*, its amendments No. 1 (1991) and No. 2 (1995), and all Collateral Standards. The numbering of sections, clauses and subclauses of this standard corresponds to that of the General Standard. The changes to the text of the General Standard are specified by the use of the following words:

"Replacement" means that the clause or subclause of the General Standard is replaced completely by the text of this standard.

"Addition" means that the text of this standard is additional to the requirements of the General Standard.

"Amendment" means that the clause or subclause of the General Standard is amended as indicated by the text of this standard.

Subclauses or figures, which are additional to those of the General Standard are numbered starting from 101, additional annexes are lettered AA, BB, etc., and additional items aa), bb), etc.

Where there is no corresponding section, clause or subclause in this standard, the section, clause or subclause of the General Standard applies without modification.

Where it is intended that any part of the General Standard, although possibly relevant, is not to be applied, a statement to that effect is given in this standard.

A requirement of this standard replacing or modifying requirements of the General Standard takes precedence over the original requirements concerned.

#### 1.3.101 Related International Standards

IEC 60601-1-2:1993, *Medical electrical equipment – Part 1: General requirements for safety – 2. Collateral Standard: Electromagnetic compatibility – Requirements and tests*

IEC 60601-1-3:1994, *Medical electrical equipment – Part 1: General requirements for safety – 3. Collateral Standard: General requirements for radiation protection in diagnostic X-ray equipment*

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 60664-1:1992, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60788:1984, *Medical radiology – Terminology*

ISO 2092:1981, *Light metals and their alloys – Code of designation based on chemical symbols*

## 2 Terminology and definitions

This clause of the General Standard applies except as follows:

*Addition before 2.1:*

In this standard, terms printed in SMALL CAPITALS are used in accordance with their definitions in the General Standard or in IEC 60788.

NOTE Attention is drawn to the fact, that in cases where the concept addressed is not strongly confined to the definition given in one of the publications listed above a corresponding term is printed in lower case letters.

An index of defined terms used in this standard is given in annex AA.

Associated conditions qualifying the usage of certain terms are given in the additional definitions below.

In this standard unless otherwise indicated:

- values of X-RAY TUBE VOLTAGE refer to peak values, transients being disregarded;
- values of X-RAY TUBE CURRENT refer to average values.

*Additional definitions:*

### 2.101

#### **CT SCANNER**

X-RAY EQUIPMENT for COMPUTED TOMOGRAPHY (CT)

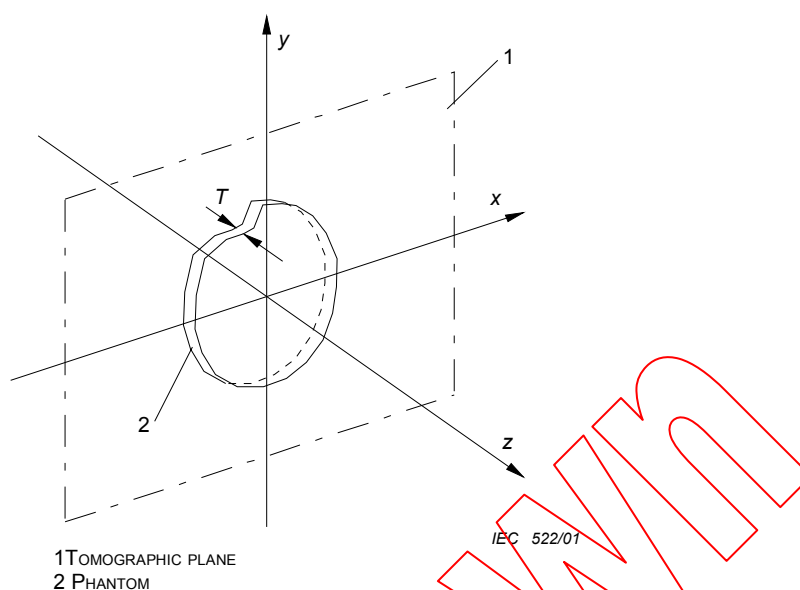
diagnostic X-ray system intended to generate cross-sectional images of the body by computer reconstruction of X-ray transmission data obtained at different angles. This generic type of device may include signal analysis and display equipment, PATIENT SUPPORT, support parts and ACCESSORIES

NOTE Secondary imaging processing is not included in the scope of this standard.

### 2.102

#### **CT CONDITIONS OF OPERATION**

all selectable parameters governing the operation of a CT SCANNER, for example NOMINAL TOMOGRAPHIC SECTION THICKNESS, PITCH FACTOR, FILTRATION, peak X-RAY TUBE VOLTAGE and either X-RAY TUBE CURRENT and LOADING TIME or CURRENT TIME PRODUCT



**Figure 101 – Coordinate system**

**2.103**

**DOSE PROFILE**

the representation of the dose as a function of position along a line

**2.104**

**SENSITIVITY PROFILE**

the relative response of a system for COMPUTED TOMOGRAPHY as a function of position along a line perpendicular to the TOMOGRAPHIC PLANE

**2.105**

**TOMOGRAPHIC PLANE**

the geometric plane perpendicular to the axis of rotation (see figure 101)

**2.106**

**COMPUTED TOMOGRAPHY DOSE INDEX 100 ( $CTDI_{100}$ )**

integral of the DOSE PROFILE produced in a single axial scan along a line perpendicular to the TOMOGRAPHIC PLANE from -50 mm to +50 mm, divided by the product of the number of TOMOGRAPHIC SECTIONS  $N$  and the NOMINAL TOMOGRAPHIC SECTION THICKNESS  $T$ :

$$CTDI_{100} = \int_{-50\text{mm}}^{+50\text{mm}} \frac{D(z)}{N \times T} dz$$

where

$D(z)$  is the DOSE PROFILE along a line  $z$  perpendicular to the TOMOGRAPHIC PLANE, where dose is reported as ABSORBED DOSE to air;

$N$  is the number of TOMOGRAPHIC SECTIONS produced in a single axial scan of the X-RAY SOURCE;

$T$  is the NOMINAL TOMOGRAPHIC SECTION THICKNESS.

NOTE 1 The term  $CTDI_{100}$  has been introduced as a more representative value for dose than the traditional  $CTDI$  integrated from  $-7T$  to  $+7T$  as defined by the FDA in 21 CFR 1020.33<sup>1)</sup>.

NOTE 2 The dose is reported as ABSORBED DOSE to air. This is required in order to avoid present confusion, as some MANUFACTURERS of CT SCANNERS express dose values calculated as ABSORBED DOSE to air and others as ABSORBED DOSE to polymethyl-methacrylate (PMMA).

Although  $CTDI_{100}$  refers to ABSORBED DOSE to air, for practical purposes the evaluation of ABSORBED DOSE to air within a PMMA dosimetry PHANTOM is well approximated by measurement of the AIR KERMA with an ionization chamber in the PHANTOM.

NOTE 3 This definition assumes that the DOSE PROFILE is centred on  $z = 0$ .

NOTE 4 A single axial scan is typically a 360° rotation of the X-RAY SOURCE.

**2.107**

**CT PITCH FACTOR**

in helical scanning the ratio of the PATIENT SUPPORT travel  $\Delta d$  along the  $z$  direction per rotation of the X-RAY SOURCE divided by the product of the NOMINAL TOMOGRAPHIC SECTION THICKNESS  $T$  and the number of TOMOGRAPHIC SECTIONS  $N$ :

$$CT \text{ pitch factor} = \frac{\Delta d}{N \times T}$$

where

$\Delta d$  is the PATIENT SUPPORT travel along the  $z$  direction per rotation of the X-RAY SOURCE;

$T$  is the NOMINAL TOMOGRAPHIC SECTION THICKNESS;

$N$  is the number of TOMOGRAPHIC SECTIONS produced in a single axial scan of the X-RAY SOURCE.

**2.108**

**TOMOGRAPHIC SECTION**

volume over which TRANSMISSION data of X-RADIATION are collected in a single axial scan

NOTE In a CT SCANNER with multiple detector elements along the  $z$ -axis, it is the volume over which data are collected by a single acquisition channel (selected grouping of elements) and not the total volume irradiated.

1) See bibliography.